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UNIVERSITY OF ALBERTA

Sedimentology and Sequence Stratigraphy of the Montney Formation in the Sturgeon Lake A and B pool

BY

Selena Mederos

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

DEPARTMENT OF GEOLOGY

Edmonton, Alberta
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Dr. T.F. Moslow (Supervisor)

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Date: Jan 21/95

ABSTRACT

A detailed sedimentologic description of 53 cores and core-to-well log correlations were made to determine the depositional origin of sedimentary facies, sequence stratigraphy and reservoir characterization of the Montney Formation in the Sturgeon Lake Field, Alberta. The Montney Formation is divided into the following 10 facies which are bioturbated siltstone (A), burrowed silty shales and sandstone (B), ripple laminated sandstone and siltstone (C), massive sandstone (D), dolomitic sandstone (E), laminated silty shales (F), dolomudstone (DM), bioclastic sandstone (NT), breccia (BR), and brachiopod wackestone-packstone (WPB). The facies are grouped into two facies associations. Facies Association 1 is a siliciclastic upward coarsening sequence (Facies A to F) deposited by storm, current and wave processes and is interpreted as a low-energy progradational lower shoreface or distal delta front (wave dominated delta). Facies Association 2 is a carbonate shallowing upward sequence (Facies DM, BR, NT and WPB) deposited in a wave dominated progradational shoreface.

The contact between Facies Association 1 and 2 is marked by a major change in lithology and is erosive. Palynological analyses reveal two missing palynologic subzones between Facies Association 1 and Facies Associaton 2 suggesting a period of erosion and/or non deposition. The boundary between the two facies associations is defined as a sequence boundary which stratigraphically divides the Montney Formation into two sequences in the study area. The Lower Montney sequence is composed of eight retrogradational, aggradational and progradational parasequences and represent a Transgressive and Highstand System Tract. The Upper Montney Sequence is composed only of one parasequence, which corresponds with Facies Association 2 and represents a Transgressive System Tract. The Montney Formation in the Sturgeon Lake Area is bounded below by the sub-Triassic unconformity in which the Lower Montney sequence is in contact with the Belloy Formation (Permian), and is bounded above by the sub-Jurassic unconformity in which the Montney and Nordegg formations are in contact.

The Sturgeon Lake A and B pool contains numerous flow units of which two are most significant with respect to lithology, porosity, permeability and geometry. The best reservoir facies in the Sturgeon Lake area is the brachiopod wackestone-packstone facies (Facies WPB) in which permeabilities may reach 8040 md. An isopach map of Facies Association 2, which consists mainly of Facies WPB, is a series of linear ridges elongated parallel or oblique to depositional strike which are only partially connected and laterally discontinuous. The siliciclastic reservoir facies consists of very-fine grained sandstones (Facies C and D) with permeabilites that may reach 132 md or more, when fractured. The

geometry of these facies is sigmoidal, elongated along depositional strike where thickness increases abruptly near the paleo-shoreline and decreases gradually basinward. Siliciclastic flow units, as well as siliciclastic and carbonate flow units, may be interconnected in some areas.

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This study examines the sedimentology, sequence stratigraphic framework and reservoir characterization of the Lower Triassic Montney Formation in the Sturgeon Lake oil field, west-central Alberta (Figure 1). The majority of previous investigations of the Triassic in the Western Canada Sedimentary Basin have focused on the stratigraphy and the tectonic setting of the Triassic units. There are few published studies that focus on detailed facies analysis, process sedimentology and sequence stratigraphy in these units. In fact, Miall (1976), is the only published detailed analysis for the Montney Formation. Recent hydrocarbon discoveries in the Montney Formation have generated significant interest within the oil industry, and created an impetus for providing a more detailed study analysis of the Montney and other Triassic units.

The present study focuses on a detailed lithofacies description and interpretation of 53 cores in order to construct a sedimentological model. It also attempts to place Montney Formation facies and facies associations in a chronostratigraphic framework through sequence stratigraphy. In addition a reservoir model is constructed to enhance the predictability of reservoir geometry and heterogeneity.

The Montney Formation is the name given of the oldest strata deposited at the eastern part of the Western Canada Basin during the Early Triassic time. This formation is commonly described as a fine-grained clastic unit of predominantly calcareous and dolomitic siltstone and shale (Gibson and Edwards, 1990). Within the lower half of the Montney Formation along its eastern erosional margin in west-central Alberta, there are several siliciclastic (sandstone) or carbonate (bioclastic) units, which are locally hydrocarbon bearing, that have been interpreted as deltaic and shallow marine deposits (Miall, 1976).

1.2 HYDROCARBON POOLS AND PROSPECTS IN THE MONTNEY FORMATION

Montney oil and gas pools occur in two principal areas (Davies *et al.*, 1992).

1. Along the up-dip margin of the erosional subcrop edge. These are coquinas (bioclastic) and siliciclastic shallow marine parasequences in small to medium size

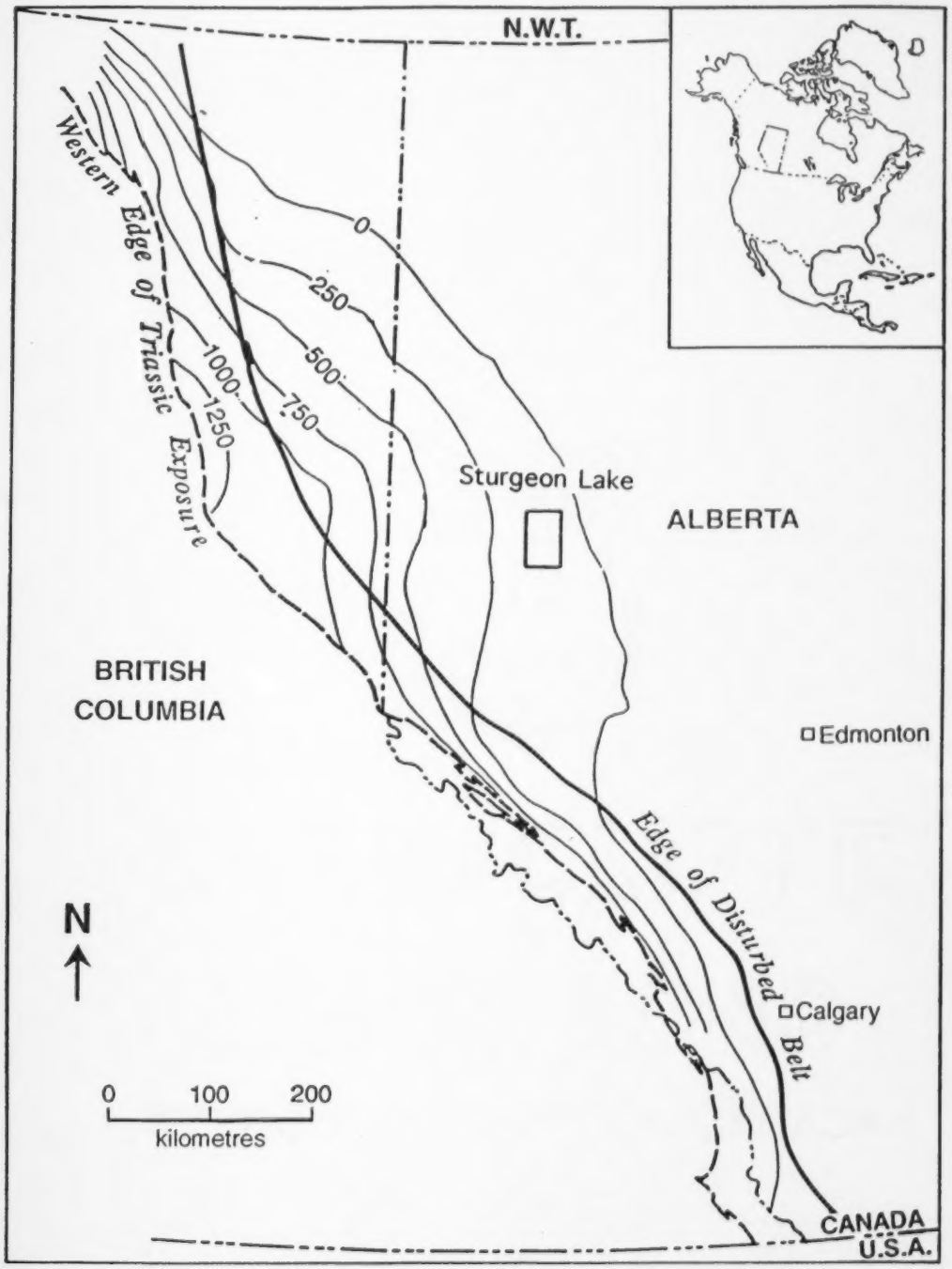


FIGURE 1: Isopach map of Triassic strata in the Western Canada sedimentary basin including the Sturgeon Lake study area. (Modified after Gibson and Barclay, 1989).

pools and include the Kaybob South, Sturgeon Lake and Sunset field in Alberta and Ring Border field in British Columbia (Figure 2).

2. To the depositional down-dip, reservoir facies such a complex of siliciclastic turbidites and down-dip lobes on a slope fan deposited in west-central Alberta area, including Sexsmith-Valhalla-La Glace and Manir Fields (Davies *et al.*, 1994).

The presence of hydrocarbons within the Montney Formation of Alberta and British Columbia appears to be contingent upon three factors:

1. The up-dip pinch out or erosion of porous reservoir beds.
2. A stratigraphic trapping mechanism provided by a Jurassic or Cretaceous unconformity, and
3. Presence within the mature hydrocarbon zone or 'window' (Podruski *et al.*, 1988) (Moslow and Davies, 1992)

Along the subcrop edge, hydrocarbon reservoirs occur in one dolomite and four sandstone 'members' while less productive reservoirs include very fine-to-fine-grained argillaceous, silty, quartzose sandstone cemented with carbonate (Miall, 1976). Pools have reservoirs with intergranular and moldic porosities ranging from 3 to 15%, net pay ranging from 2.7 to 7.0m and recovery factors from 11 to 25% (Podruski *et al.*, 1988).

The largest field, Kaybob, produces from bioclastic dolomitic units ('coquina') with 64500 MSTB of recoverable oil (Miall, 1976). The Sturgeon Lake South field, within the third and fourth members of Miall (1976), has poorer reservoir quality than the Kaybob South field (Miall, 1976).

The potential initial in-place volume for the Montney Subcrop South-Fir is 23258 $x10^6m^3$ which is likely to be discovered in 427 pools. New pools are anticipated in local facies pinch-out traps or at the erosional edge (Bird *et al.*, 1994). Potential for undiscovered pools is in the poorly drilled northeast part of the play which are close to the subcrop zone. Montney Distal Shelf-Glacier have significant potential. An estimate of expected potential for this play is given at $12191x10^6m^3$ calculated using all Triassic plays in a discovery process model (Bird *et al.*, 1994). For the Montney Subcrop North-Ring there is an expected potential of $15.971x10^6m^3$. The play has some potential to the northwest but may be limited by an unfavorable change in lithology while southeast the sub Cretaceous unconformity downcuts into the reservoir leaving just a thin section (Bird *et al.*, 1994).

Figure 3 shows the play size by rank of 10 mature Triassic plays where Montney is placed fifth in the play rank (Bird *et al.*, 1994) and finally Figure 4 shows some reservoir

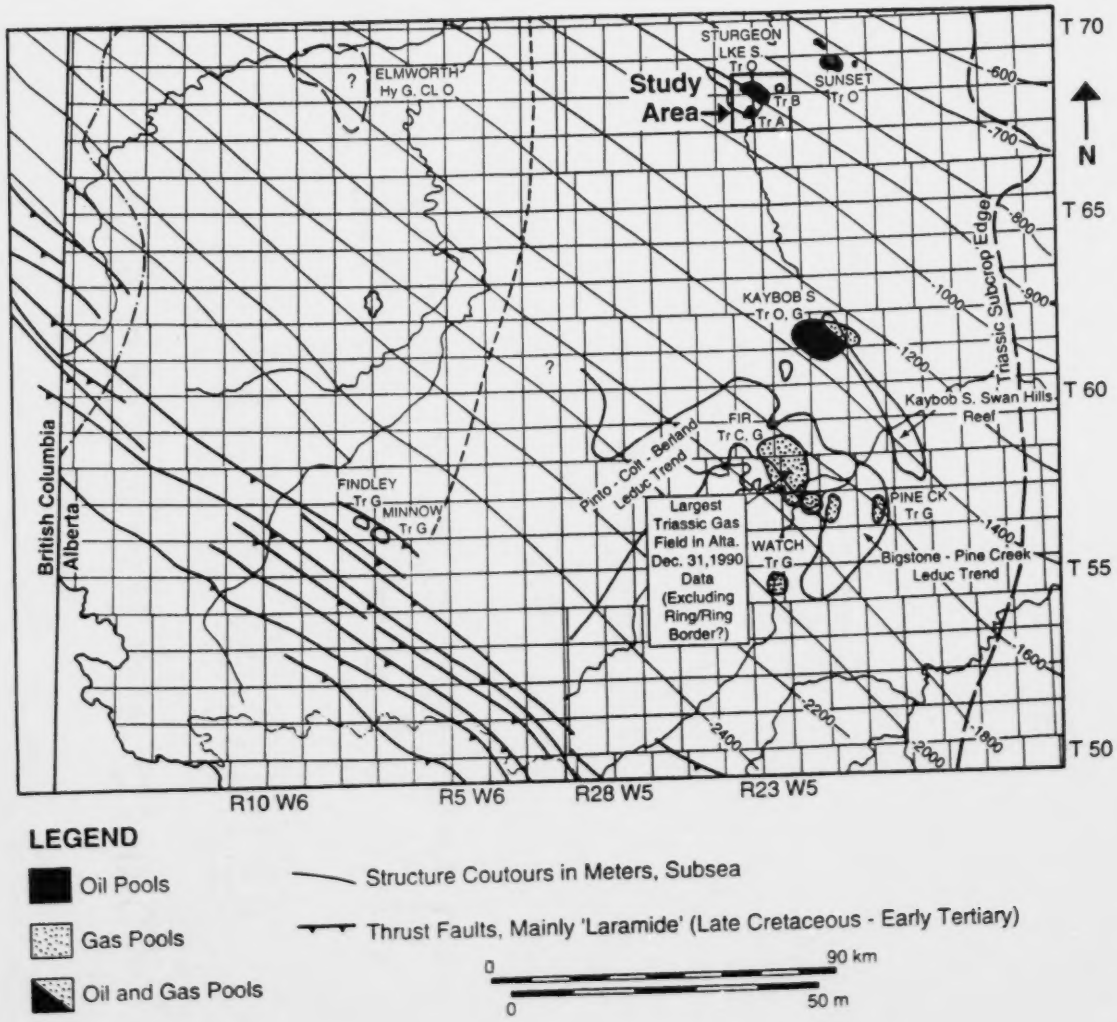


Figure 2: Map Showing the distribution of major Montney Formation oil and gas fields that occur along the up-dip margin of the erosional subcrop edge in west-central Alberta. The Sturgeon Lake study area is shown. (Modified after Davies et al, 1992)

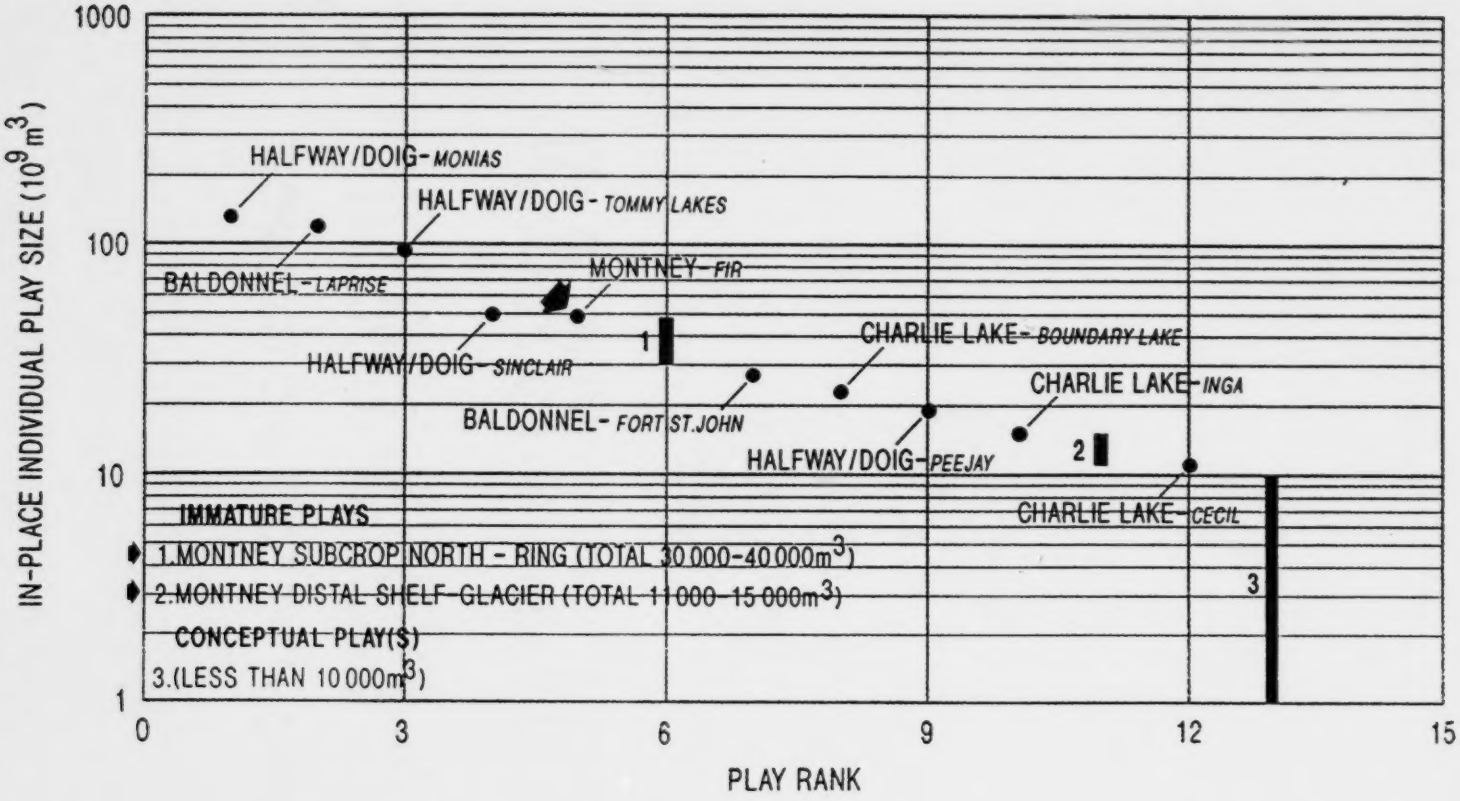


Figure 3: Play size-by-rank plot of the 10 mature Triassic plays. Dots show total resources (Discovered plus undiscovered) of mature plays; boxes represent range of total resource for immature and conceptual plays. (After Bird et al, 1994).

Montney Subcrop South – Fir play, reservoir parameters and assessment results

Rank	Field/Pool	Gas type	In-place volume (10^6m^3)	Disc. date	Net pay (m)	Area (hect.)	Depth (m)	R.F.	Por.	S.W.
1	Fir, Triassic C	NA	9 974	71/12/12	2.3	22 527	2 661	0.80	0.10	0.20
2	Kaybob South, Triassic A	AG + SG	5 552	62/12/06	"	"	2 055	0.53	"	"
3	Oldman, Tria Sys	NA	2 361	77/05/15	3.8	2 473	2 897	0.80	0.15	0.15
4	Kaybob South, Triassic B	NA	2 206	75/12/28	3.5	1 721	2 377	0.80	0.11	0.25
8	Sturgeon Lake South, Triassic A	AG + SG	578	56/11/22	1.8	335	1 498	0.75	0.15	0.35
28	Ante Creek North, Triassic A	NA	252	54/07/29	3.6	505	1 868	0.90	0.11	0.30
30	Sundance, Triassic A	NA	229	74/06/04	1.6	718	3 230	0.75	0.08	0.25
31	Dixonville, Tria Sys	NA	219	58/11/20	5.2	440	841	0.80	0.20	0.30
32	Sturgeon Lake South, Triassic B	AG + SG	217	56/02/18	1.4	607	1 539	0.75	0.14	0.45
33	Ansell, Triassic A	NA	217	77/11/10	3.7	400	3 077	0.75	0.09	0.20
39	Plante, Tria Sys	NA	188	76/12/30	3.7	200	2 981	0.80	0.15	0.40
40	Kaybob South, Triassic A	AG	187	62/12/06	1.8	782	2 091	0.75	0.10	0.25
41	Fir, Tria Sys	NA	186	78/03/10	3.3	400	2 632	0.75	0.09	0.30
48	Jack, Mont	NA	161	78/05/28	1.9	1 095	1 096	0.70	0.16	0.40
49	Whitelaw, Triassic A	NA	159	51/03/26	4.9	200	1 009	0.90	0.21	0.30
50	Plante, Mont	NA	156	80/12/11	5.2	200	3 002	0.75	0.09	0.15
53	Plante, Trias Sys	NA	148	66/02/12	2.8	128	2 914	0.80	0.20	0.25
61	Obed, Mont	NA	130	81/05/20	4.1	200	3 535	0.75	0.11	0.40
63	Normandville, Tria Sys	NA	127	81/05/21	9.0	200	910	0.75	0.13	0.30
64	Tangent, Triassic D	NA	125	51/08/02	1.5	200	868	0.75	0.23	0.25

Total initial in-place volume (discovered)	25 876
Total initial in-place volume (potential)	23 258
Per cent play resource undiscovered	47
Total pools discovered	73
Total pool population	500

Figure 4: Montney Subcrop South-Fir play, reservoir parameters and assessment results including Sturgeon Lake A and B pool (After Bird et al, 1994).

parameters of the different fields of the Montney subcrop within which Sturgeon Lake A and B are included.

The Triassic remains an active exploration target with significant potential as shown by drilling activity and recent discoveries at Spirit River (1983), Brassey (1987), Ring Border (1988), Sukunka (1989), Sexsmith, Valhalla and La Glace (1992) and Manir (1993) (Bird *et al.*, 1992; Davies *et al.*, 1994).

1.3 PREVIOUS WORK

The Triassic of northwestern Alberta was first divided by Hunt and Ratcliffe (1959) into the Charlie Lake, Halfway and Toad-Grayling Formation. In 1962 Armitage subdivided The Toad-Grayling into two units, the Montney and Doig, because the initial subdivision could not be practically applied to the subsurface. Gibson (1975) indicated that the Montney, Grayling, and lower part of the Toad Formation, and the Vega-Phroso Siltstone Member were deposited on an 'open shelf, in relatively deep water', during an easterly to southeasterly marine transgression.

Numerous studies of the Triassic System within the Western Canada Sedimentary Basin have been conducted (*i.e.* Torrie (1973), Cant (1986), Aukes and Webb (1986), Campbell and Horne (1986), Barclay and Leckie (1986) Willis and Moslow (1994, a, b)). Biostratigraphic studies include Warren (1945), Tozer (1961, 67, 82, 84) and Silberling and Tozer (1968). Studies of Triassic tectonics include those by Tozer (1982) and Monger (1989) which indicated that major tectonic events do not appear to have been major influences on Triassic deposition. Gibson and Barclay (1989) and Gibson and Edwards (1990), however, indicated episodic movement of horst and graben fault blocks on the Peace River Arch. Moslow and Davies (1992) suggested active volcanism during Early Triassic time.

Gibson and Barclay (1989) in their study of the Triassic System, observed a thickness of 1200m for the Triassic succession. This strata thins eastward to an erosional edge (Figure 1) where the principle area of deposition was in the Peace River Arch region. They also subdivided the Triassic in three transgressive-regressive assemblages in which the lower Montney and Grayling formations and lower Vega-Phroso Siltstone Members represent the transgressive component of the first assemblage. The regressive component comprises the upper part of the Montney and lower Toad formations and the upper Vega-Phroso and Vega Siltstone members (Figure 5). Miall (1976) recognized four porous members in the lower half of the Montney Formation within the Sturgeon Lake and Sunset

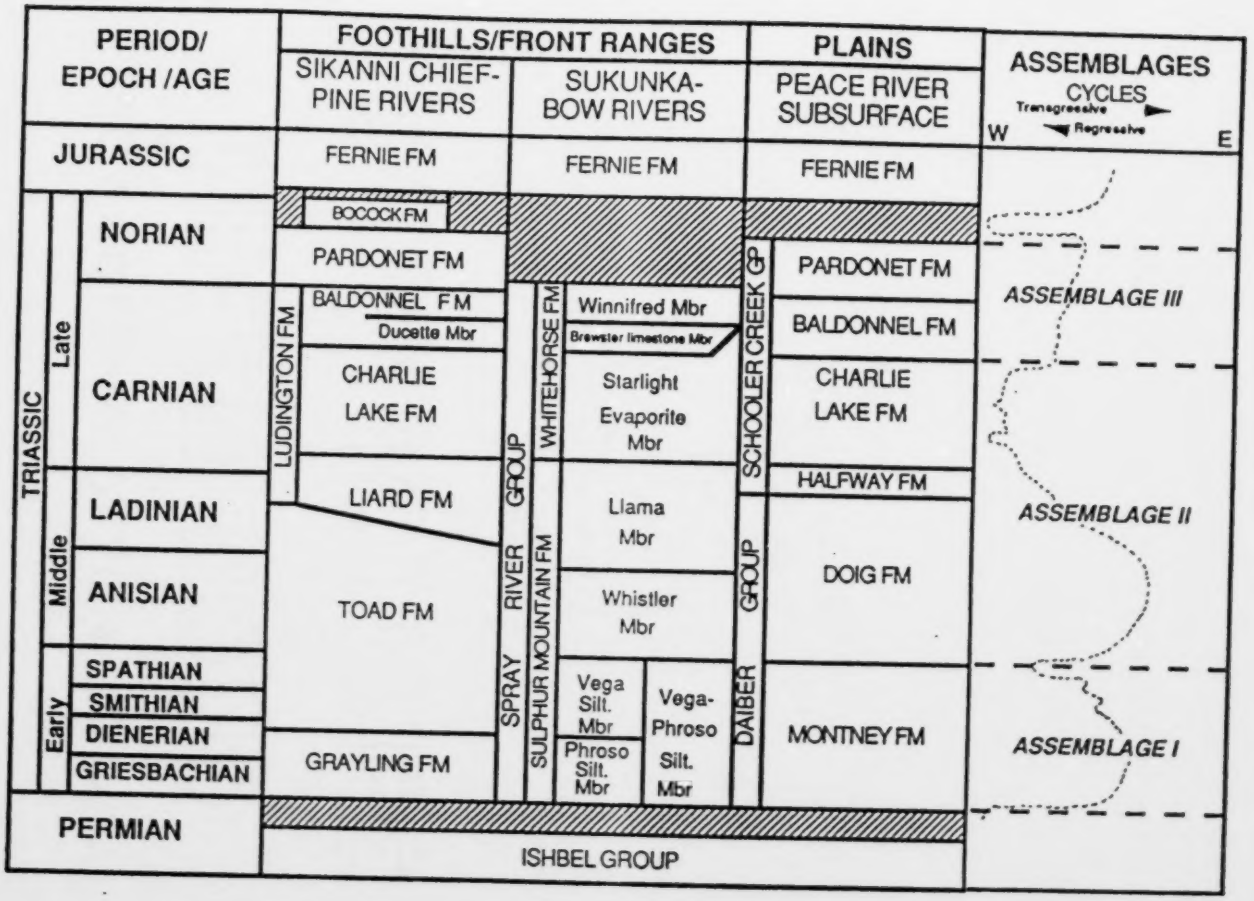


Figure 5: Nomenclature and correlation chart of Triassic Formations, members and depositional assemblages, Western Canada Sedimentary Basin (After Gibson and Barclay, 1989).

fields, consisting of sandstone and dolomitic coquina (Figure 6) which he interpreted to have been deposited in 'shallow water deltaic' and/or 'proximal shelf' environments.

Gibson and Edwards (1990) described the lithological characteristics, gamma ray responses and the thickness trends of the Montney Formation and interpreted that it was deposited in 'relatively deep water shelf to shallower water proximal shelf and deltaic' environments from west to east, during a major transgressive-regressive event. Davies *et al.*, (1994) conducted sedimentological and sequence stratigraphic study on the Montney Formation in west central Alberta in the developing plays of Glacier, Valhalla, Sexsmith, La Glace, Manir, and other trends. He indicated that the subsurface Montney in west-central Alberta is a complex of turbidite channel, turbidite channel margin and turbidite lobe facies association while the Coquinal Dolomite Unit in the eastern part was deposited in a slightly deeper condensed environment to a shallower, shoreface and/or tidally influenced setting. Podruski *et al.*, (1988) and Bird *et al.*, (1994) analyzed the oil and gas resources of Western Canada and defined the Montney play and its potential.

Riediger *et al.*, (1990) analyzed the geochemistry of Montney Formation shales as potential source rocks indicating that in British Columbia the Montney is overmature but may have generated significant quantities of hydrocarbon earlier in its thermal history. The Montney of Alberta is less mature and contains very little organic matter (Riediger *et al.* , 1990). Riediger (1994) studied the migration of 'Nordegg' oil in WCSB and indicates that some 'Nordegg' oil has been expelled downward into subcropping Triassic and Permian reservoirs. Oils in the Kaybob and Sturgeon Lake fields (Montney reservoirs) are suspected of having a 'Nordegg' source, but their high level of thermal maturity prevents reliable oil-source rock correlations based on biomarker data (Riediger, 1994).

1.4 OBJECTIVES

The main objectives of this study are to:

1. Provide a process sedimentologic description and identification of subsurface Montney sedimentary facies in the Sturgeon Lake Area, Alberta (Figure 2), in order to determine the environment of deposition;

2. Construct lithofacies associations representative of the most commonly recurring vertical successions of sedimentary facies;

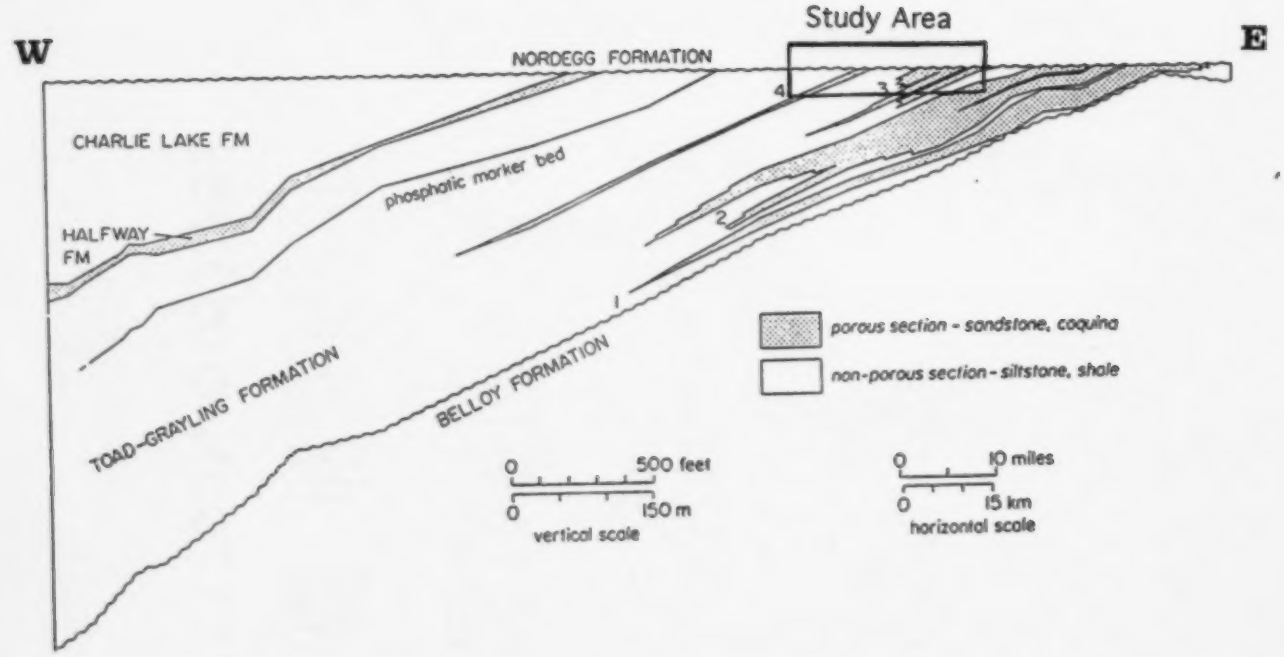


Figure 6: Regional cross-section through the Triassic of northwestern Alberta showing distribution of the four porous members in the Toad-Grayling Formation, including study area (Modified after Miall, 1976).

3. Laterally correlate the vertical lithofacies association in order to construct a depositional model of the Montney Formation and consequently determine the geometry, heterogeneity and distribution of reservoir facies;

4. Determine the relationship between facies and petrologic characteristics (such as sorting, mineralogy, grain shape, grain size, and distribution, fabric, porosity, permeability etc.) which influence reservoir quality; and

5. Construct a sequence stratigraphic framework of the Montney Formation to provide a chronostratigraphic framework for facies analysis and thus allow a better exploration strategy on a regional scale.

1.5 STUDY AREA

The Sturgeon Lake South A and B pools are located in Townships 68 and 69, Ranges 21 and 22 west of the 5th Meridian. The area is roughly 10km south of the town Valleyview, and covers approximately 373km^2 (Figures 1 and 7).

The Sturgeon Lake A and B pools have a subsurface database of 250 wells and 53 Triassic (Montney) cores. The majority of wells in the study area were drilled in the 1960's. Thus, the resolution and variety of most of the wire-line logs is relatively poor. Nevertheless, the available database is substantial and permits us to apply process sedimentology and sequence stratigraphy in analyzing Montney facies.

1.6 METHODS

This study involves the sedimentologic description of 53 cores of the Montney Formation in the study area (Figure 7). The length of the cores varies from 7.9m to 35m with a mean length of 15.2m. The cores, located at the ERCB in Calgary, were slabbed and unslabbed. Observations were recorded on a core description sheet at a scale 1:30 (1cm=1ft). The core description sheet has standard parameters including: grain size, basic rock type, burrowing, sedimentary structures, bed thickness, cement/accessories, sorting, photo/sample number and comments. These descriptions are contained in Appendix A. Each core was subdivided into different facies, based on lithology, texture and physical and biologic sedimentary structures. Vertical variation within and between each facies were

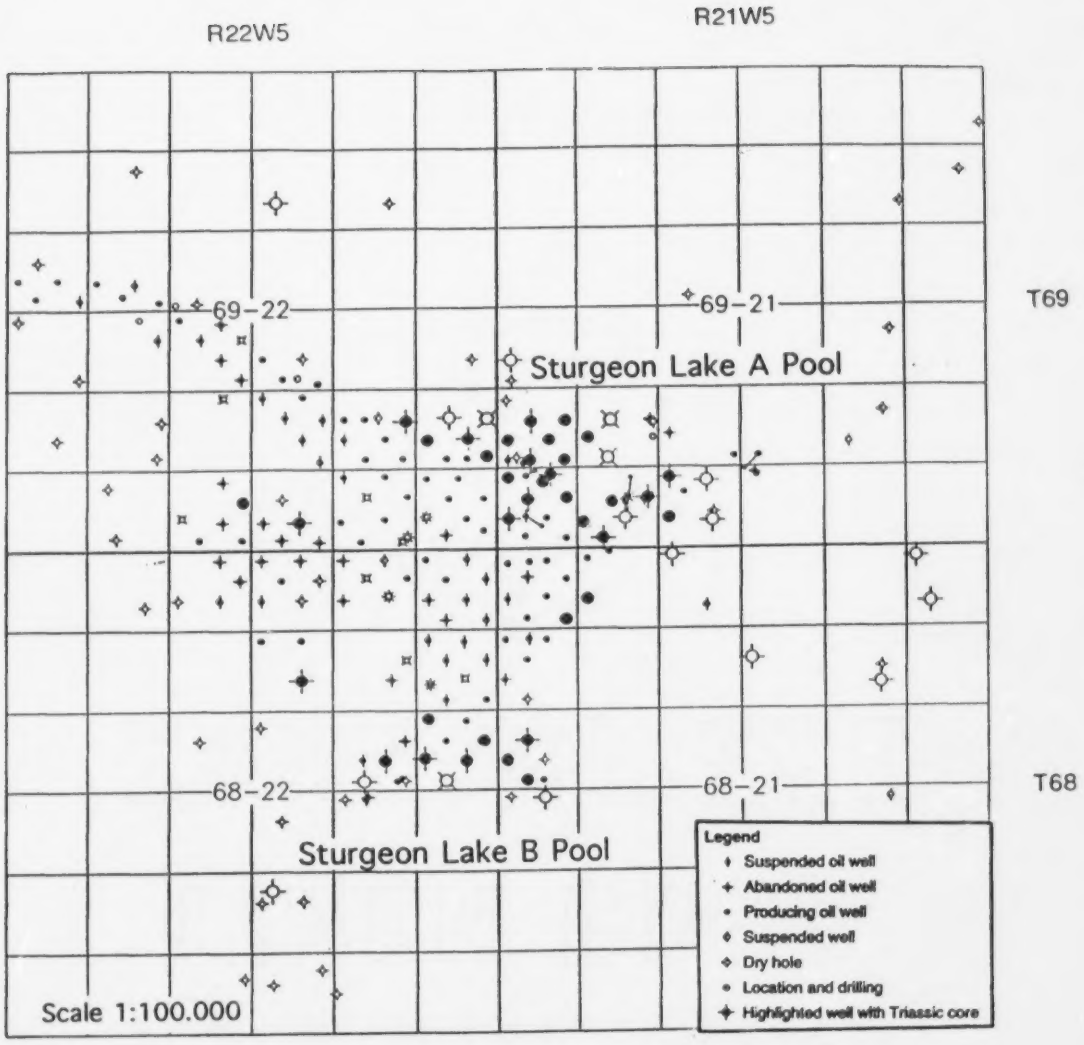


Figure 7: Map showing the location of the 250 wells penetrating the Montney formation in Sturgeon Lake A and B Pools. Wells with Triassic cores are highlighted (Map provided by Unocal Canada Limited).

described and the nature of bounding surfaces and lithological contacts was determined. Trace fossil assemblages were identified with the invaluable help of the ichnology group of the University of Alberta to complement environmental and process sedimentology interpretations. One hundred and twenty-four core samples were obtained in order to conduct petrographic analysis and 31 thin sections of the most permeable facies (fine grained siltstones and dolowackestones were analyzed focusing in mineralogy and classification of the sample, sorting, grain size, porosity percentages and types. Thin sections of non-reservoir facies like Sedimentary Breccias (BR) were analyzed to see the textural and mineralogical characteristics of the intraclasts and matrix. All the petrographic analyses are contained in Appendix B.

Core logs and Gamma Ray, Spontaneous Potential and Resisitivity logs at the same scale (1:30) were calibrated to exactly locate the cored part in the well log and also to establish a facies=log response relationship to extrapolate facies locations where there were no cores. This was possible only in cores where the Nordegg Formation was present because the Montney/Nordegg contact is an abrupt and contrasting change in facies (Siltstones or Carbonates to Black Shales) and in wire log response. Depositional dip and strike orientated facies cross-sections were constructed to predict geometry, distribution, lateral and vertical variability, orientation and heterogeneity of reservoir intervals. A data base, general isopach map of the Montney in the Sturgeon Lake Area and structure contour maps at the top of the Permian and top of the Montney were provided by Doug Glass (Unocal Canada Limited) in order to help in the construction of more detailed and specific isopach maps in the reservoir facies of the Montney and to see if the tectonic and the structure have a major influence during the deposition of the Montney Formation in the Sturgeon Lake Area. Detailed isopach maps of reservoir facies clastics and carbonates using core and well log data were constructed to reconstruct the geometry of the reservoirs and extrapolate the geometry of the parasequences in the Sturgeon Lake A and B pool.

Stratigraphic dip (AA', Figure 8) and strike (BB', Figure 8) orientated cross-sections were constructed to put facies associations in a chronostratigraphical framework at a field scale (Sequence Stratigraphy of the Montney Formation in the Sturgeon lake A and B pools). Gamma Ray, Spontaneous Potential and Resistivity logs were used for facies association correlation because the properties that they measure are most helpful in identifying lithologies.

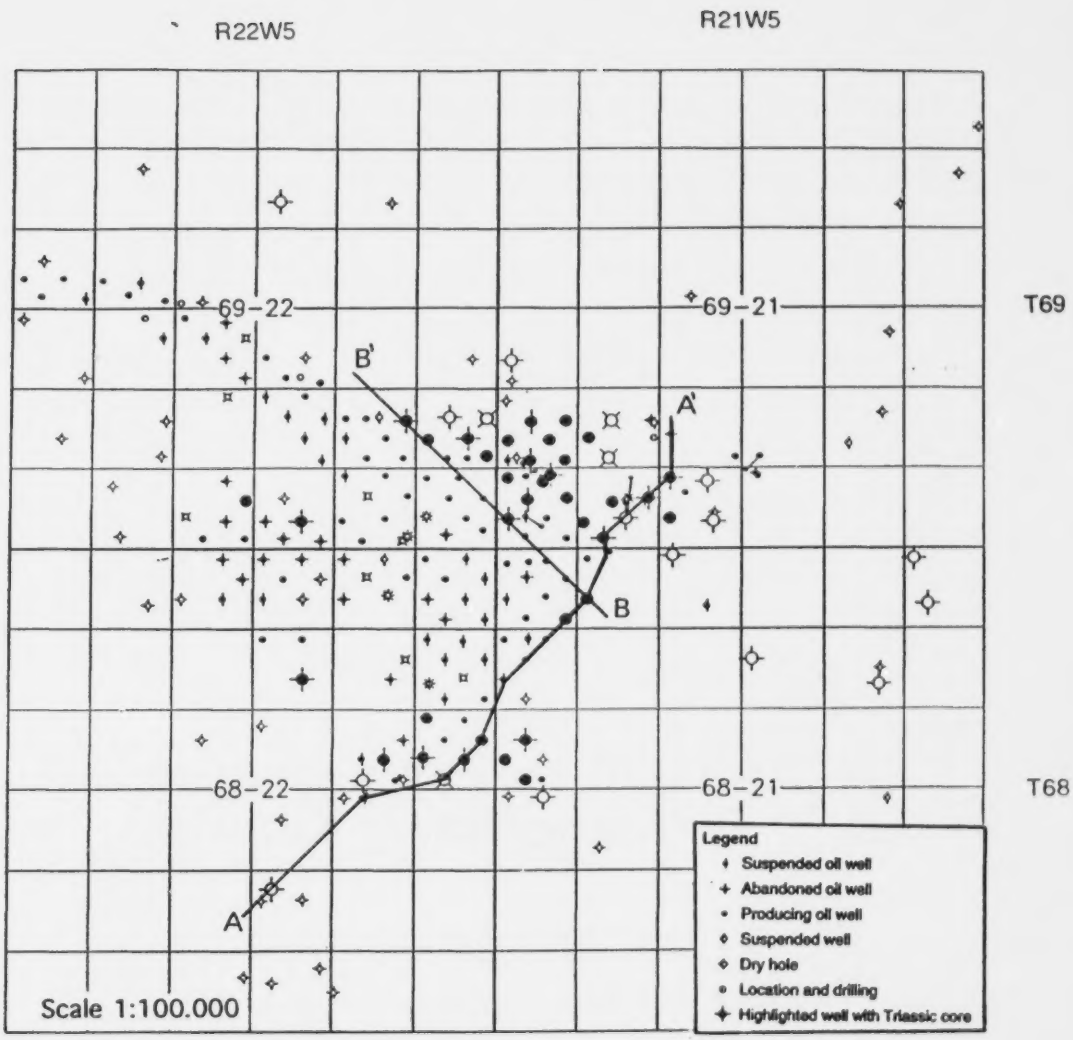


Figure 8: Map showing the location of the stratigraphic dip (AA') and strike (BB') orientated cross-section.

2 REGIONAL STRATIGRAPHY

The Triassic System in Alberta and British Columbia forms one of the most lithologically variable successions of the Western Canada Sedimentary Basin. Occupying for the most part an elongate narrow belt extending from the United States in the south to approximately the British Columbia-Yukon border in the north (Gibson and Barclay, 1989) (Figure 1). The Triassic deposits represent a broad range of sedimentary facies. Distal shelf/platform siltstone, shales and limestones occur in the lower Triassic units. Shallow water shelf/platform and shoreface siltstones, shales, sandstone, and carbonates occur midway through the succession. The upper Triassic contains variegated shallow water to beach, tidal inlet, tidal flat and sabkha carbonates, evaporites, sandstones and siltstones (Gibson and Barclay, 1989). Triassic strata of the Western Canada Sedimentary Basin rest unconformably on Permian rocks in the west and onlap Mississippian carbonates eastward. Throughout most of the basin, the Triassic is unconformably overlain by shales of the lower Jurassic Fernie Group (Nordegg Member), but in parts of northeastern British Columbia the lower Cretaceous Gething or Bluesky Formations immediately overlie the Triassic (Willis, 1992).

Faunal assemblages for outcrop sections in the foothills range in age from Griesbachian to Norian, a period of some 37 million years (Tozer, 1961; 1967). This sequence forms what is probably the most completely described Triassic biostratigraphic succession in the world (Harland *et al* ., 1989, from Willis, 1992).

Three nomenclatural systems have been adopted for Triassic strata within the Peace River Arch area (Figure 9). In exposures of the Foothills between the Sukunka-Pine River and Williston Lake area, the strata are referred to in ascending order as the Grayling, Toad, Liard, Charlie Lake, Baldonnel, Pardonet and Bocock Formations. Exposures south of the Sukunka-Pine River area are called the Spray River Group (Sulphur Mountain and Whitehorse formations, Gibson, 1975). In the subsurface Foothills and Interior Plains, Triassic strata/units are identified in ascending order as the Daiber (Montney and Doig formations) and Schooler Creek groups (Halfway, Charlie Lake, Baldonnel and Pardonet formations) (Gibson and Edwards, 1990). A summary of the present correlation of Triassic outcrop and subsurface sections is shown in Figure 9.

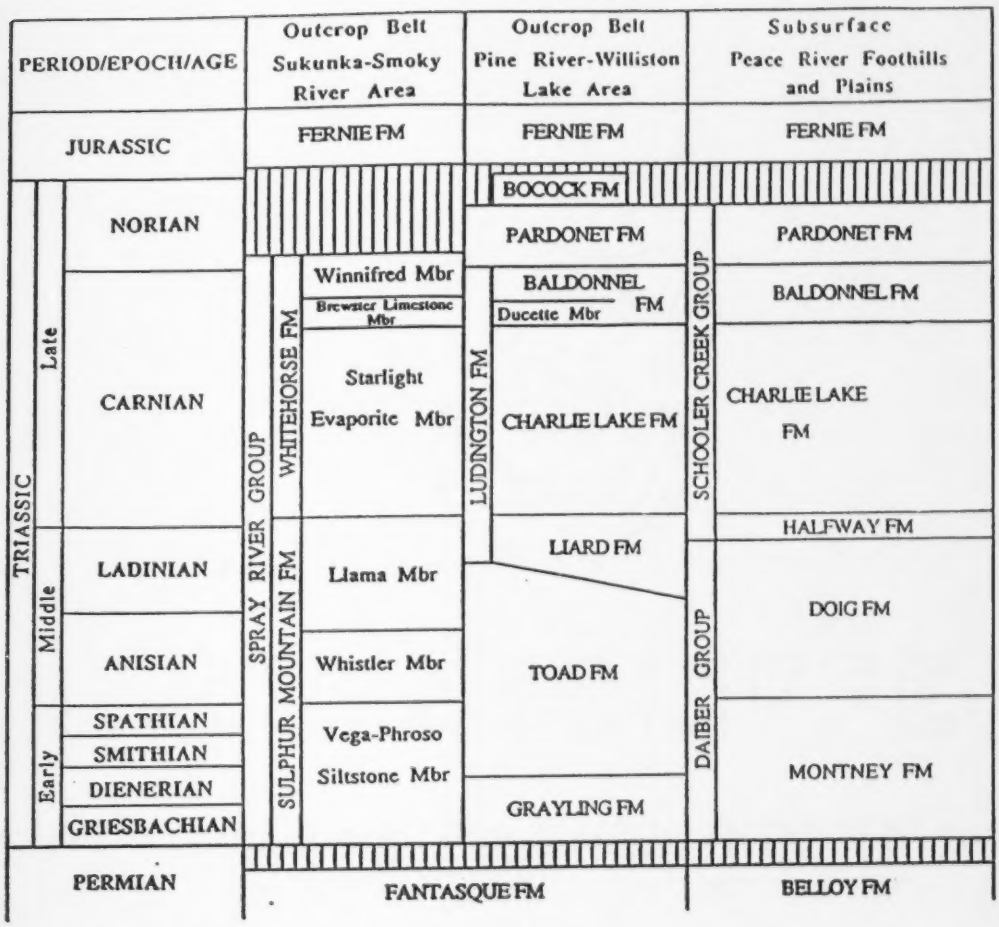


Figure 9: Table of formations, Peace Rive Arch area, northeastern British Columbia (After Gibson and Edwards, 1990).

2.1 DAIBER GROUP

The Daiber Group was first defined by Armitage (1962). He proposed that the use of the term Toad-Grayling formations for the sequence below the Halfway Formation in the subsurface be discontinued and that the Triassic beds below the Schooler Creek Group in the subsurface be raised to group status as the Daiber Group (Armitage 1962; in Willis, 1992). The Type Locality of the Daiber Group is a well in the Peace River area. The Texaco N.F.A. Buick Creek No. 7 well is located in 6-26-87-21W6, 41.6km (26mi) northwest of Fort St. John, British Columbia.

The Daiber Group consists predominantly of grey siltstones and shales, divided into two lithological units: a lower, argillaceous siltstone unit which grades into grey shale at the base (Montney Formation) and an upper dark grey, bituminous siltstone and sandstone unit (Doig Formation) (Glass, 1990). The Daiber Group thins from more than 610m in the foothills to zero at its easterly subcrop edge. This group conformably overlies Permo-Carbonaceous quartzites and cherts, or carbonates of the Mississippian where the Perm-Carboniferous has been eroded. It is overlain by the Halfway Formation, and the contact appears disconformable (Glass, 1990) nevertheless, Willis and Moslow (1994 a,b) and Caplan (1992) suggest that it is conformable. At its erosional subcrop limit the Daiber Group may be overlain by Jurassic or Cretaceous beds.

2.2 MONTNEY FORMATION

The Montney Formation was first defined by Armitage in 1962 as part of the Diaber Group. The lower Montney is a dark grey, dolomitic siltstone, interbedded with shales. The upper Montney is a light brown, siltstone with interbedded fine grained sandstones. Along the eastern depositional margin, the Montney is characterized by hydrocarbon bearing sandstone and dolomitized bioclastic sandstone ('coquina') (Gibson, 1993). The Montney Formation reaches its maximum thickness in the foothills and Deep Basin area being 1280m (918ft) at Nose Creek to 200m (656ft) at Kakwa respectively and thins to an eastern erosional edge near the town of Peace River, northwestern Alberta and south of Fort Nelson, northwest British Columbia (Gibson, 1950). The Montney Formation unconformably overlies the Permian Belloy Formation and is abruptly overlain in most areas by phosphatic silty shales of the Doig Formation (Gibson and Edwards, 1990). The Montney may be overlain by Jurassic or Cretaceous beds at its eastern erosional limit (Glass, 1990). The 'Worsley Member' or 'Tangent dolomite' which has not been assigned

to a formation is generally thought to be Triassic (Late?) in age, may unconformably overlie the Montney Formation (Edwards *et al.*, 1994).

The Montney Formation is interpreted to have been deposited within a relatively deep water shelf environment during a major transgressive-regressive event. The coarser grained siltstone, sandstone and coquina facies to the east were deposited in a shallow water, deltaic environment (Miall, 1976), or in a shallower water proximal shelf environment (Gibson and Barclay, 1989). Davies *et al.*, (1994) interpreted fine grained sandstones and coarse siltstones in the west central Alberta area to have been deposited by turbidity current processes as a series of turbidite channels and lobes on a shelf ramp setting. The Montney Formation, because of its equivalence to the Grayling and lower Toad Formations and the Vega-Phroso Siltstone Member of the Sulphur Mountain Formation in the foothills to the west, is interpreted to be Early Triassic in Age (Gibson *in press*, in Gibson and Edwards, 1990).

2.3 SCHOOLER CREEK GROUP

The Schooler Creek Group was first defined by McLearn (1921) and amended by Hunt, and Ratcliffe (1959). The Type Locality of this group is from the subsurface Peace River Plains in northeastern British Columbia, in the following two wells: a) Pacific Fort St. John No 16, in 2-18-84-19W6M from 1257.9 and 1565.2m and, b) Southern Production No B-14-1, in 1-12-84-23W6M, from 1524 and 1569.1m (Glass, 1990).

This group comprises six formations which, in ascending order, are:

1. *Halfway or Liard*- dolomitic to calcareous sandstone, with lesser beds of siltstone, dolostone and skeletal limestone;
2. *Charlie Lake*- intercalated dolomitic to calcareous sandstone, siltstone, sandy limestone, dolostone and minor intraformational and or solution breccia;
3. *Ludington*- a lateral equivalent of the Charlie Lake, Baldonnel and Liard formations, comprising medium to pale grey weathering, dolomitic to calcareous siltstone, sandstone and silty to sandy bioclastic limestone;
4. *Baldonnel*- a pale grey to brownish grey limestone and dolostone;
5. *Pardonet*- grey and brownish grey carbonaceous-argillaceous limestone, silty limestone, calcareous and dolomitic siltstone and minor shales, and
6. *Bocock*- aphanitic to coarsely crystalline to bioclastic limestone. (Gibson and Edwards, 1990) (Figure 9).

In the subsurface, the Schooler Creek Group is recognized throughout the Rocky Mountain Foothills and Peace River Plain to have a maximum thickness of 730m near the headwaters of Eleven Mile Creek, south of Williston Lake, and thins to zero toward the east and northeast. The Schooler Creek Group conformably and gradationally overlies the Toad/Doig formations. In the subsurface, this contact can be disconformable. The top of this Group is unconformably overlain by the Jurassic Fernie Formation or the Lower Cretaceous Bullhead and Fort St. John Groups.

2.4 LATERAL EQUIVALENT OF THE MONTNEY FORMATIONS

The Grayling and the lower Toad Formations are lateral equivalents of the Montney Formation in the foothills between the Sukunka-Pine River and Williston Lake areas (Figure 9). The Grayling Formation comprises a regional uniform, dark grey sequence of dolomitic siltstone, silty shale and lesser calcareous siltstone, silty limestone, dolostone and very fine grained sandstone. The thin bedded, fine-parallel-laminated character, absence of wave and/or current ripples and occurrence of pyritiferous laminae, suggest deposition in a relatively deep, partly euxinic distal shelf environment (Gibson and Edwards, 1990).

The Toad Formation comprises a succession of dark grey, thin to medium bedded, shaly to flaggy weathering, very calcareous siltstone, silty limestone, silty shale and minor amounts of silty dolostone and calcareous sandstone (Gibson and Edwards, 1990). Sedimentary structures consist of regular wavy, parallel to lenticular lamination. This unit is interpreted to have been deposited in a distal shelf environment, one shallower than that postulated for the strata of the underlying Grayling Formation.

The Vega-Phroso Siltstone Member, equivalent to the Montney Formation in southern Alberta, consists of a dark brownish grey siltstone, finely crystalline to skeletal limestone, shale and minor quartz sandstone (Gibson, 1993). In part of the Front Ranges and Foothills of the Athabasca-Bow River region the Vega Siltstone Member is characterized by an additional unit called the Mackenzie Dolomite Lentil. This unit is hydrocarbon bearing. The main facies of the Mackenzie lentil consists of medium to coarsely crystalline dolostone with thin intervals or beds consisting of fragmented dolomitized bivalve shells (Gibson and Poulton, 1994). Facies assumed equivalent to the Mackenzie Dolomite have been observed in outcrop as far south as Cascade River in Banff National Park (Gibson, 1994). The Mackenzie Dolomite is interpreted by Gibson and Poulton (1994) to have been deposited mainly within a proximal shelf or shoreface, however it seems to be deposited farther offshore at the Cadomin locality.

3 TRIASSIC TECTONIC SETTING

The Peace River Embayment of Alberta and British Columbia (Figure 10) was developed during Early Carboniferous and Permian time. During Triassic time, the Embayment persisted and subsided as a broad downwarp associated with minor block fault rejuvenation, particularly in the Monias area and southwest of Fort St. John (Edwards *et al.*, 1994). In the Peace River Arch episodic movement of horst and graben fault blocks has influenced sedimentation patterns and petroleum trapping mechanisms (Gibson and Barclay, 1989; Caplan, 1992). Locally, sediment loading is indicated by deformed bedding and slump structures (Wittenberg, 1993). Also, localized small-scale (10-20m) faults, generally formed in subparallel sets, have influenced Triassic deposition (Cant, 1986; Wittenberg, 1993; Edwards *et al.*, 1994). Moslow and Davies (1992) observed bentonite clay beds in certain cores from the Lower Triassic Montney Formation in the Ring Border area of northeastern British Columbia . This would suggest active volcanism along the continental margin during at least Early Triassic time. In the Doig interval, Moslow and Davies (1992) identified siliclastic facies deposited in a continental shelf environment, subject to sea floor instability. There is evidence of Triassic subduction along the cratonic margin in Southern Alberta (Davies *et al.*, 1978). It is probable that subduction was also occurring along the western Canadian cratonic margin during the same time, but direct evidence of this has subsequently been displaced northward (Willis, 1992). Monger (1989) summarized the tectonic setting for the western cratonic margin during the Triassic as a 'complex passive margin, with varying rates of extension, subsidence and flexure'.

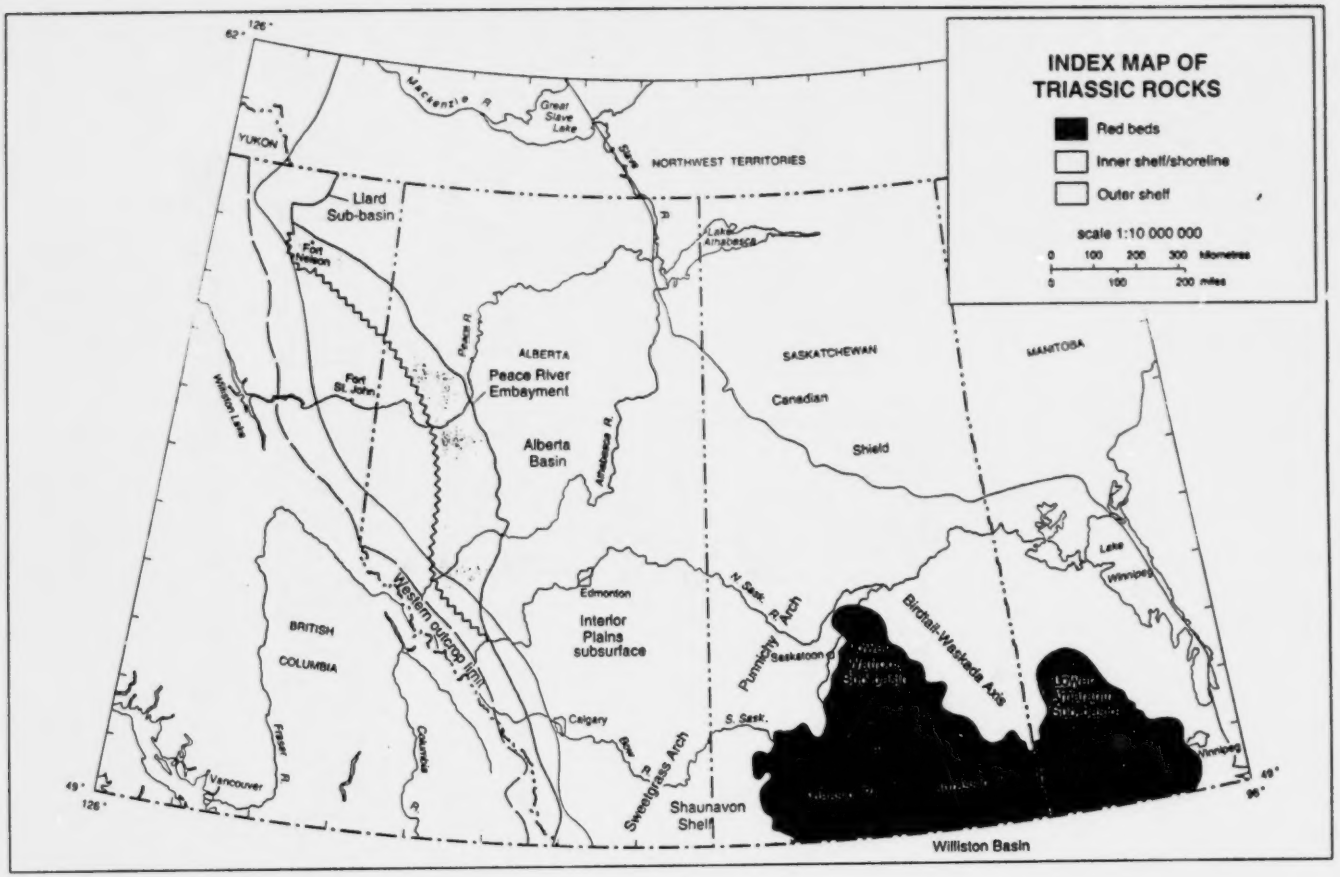


Figure 10: Map of Triassic rocks in the Western Canada Sedimentary Basin showing the Peace River Embayment (After Edwards, et al 1994).

4 SEQUENCE STRATIGRAPHY: Sea Level Fluctuations during the Triassic: Nature of sedimentation

Triassic sea-level changes are not well documented because of the scarcity of Triassic marine strata over many of the continental interiors and passive continental margins (Embry, 1988). The Salt Range in Pakistan is a well exposed, paleontologically rich succession, late Permian to early Triassic in age, which is why Haq *et al.*, (1988) chose it as the global reference section for the latest Permian and early Triassic interval (Figure 11). The general features for Triassic chronostratigraphy and eustatic sea level cycles are shown in Figure 12.

Embry (1988) established the stratigraphic pattern for the Triassic succession in the Sverdrup Basin of the Canadian Arctic Islands. This pattern consists of thick progradational wedges of deltaic and marine strata, alternating, with thin, transgressive, clastic units (T-R cycles) (Figure 13a). Embry (1988) believes that the origin of the T-R cycles are related to eustatic sea-level rises and falls on a background of thermal subsidence and fluctuating sediment supply, rather than alternating tectonic uplift and subsidence. T-R cycles or assemblages have also been described for the Western Canada Sedimentary Basin (WCSB). Gibson and Barclay (1989) divided the Triassic rocks for the WCSB into three main facies assemblages which in most areas coincides with three regional T-R marine cycles. The three facies assemblages in ascending order are:

1. Early Triassic, distal shelf to shoreline siliciclastic and lesser carbonate rocks.
2. Middle to early Late Triassic, shoreline-sabkha siliciclastic, carbonate and evaporite rocks.
3. Late Triassic, shallow to deep water shelf and shoreline carbonate.

The cyclical character of each assemblage appears to correlate with transgressive-regressive cycles seen in other North American basins (*e.g.* Embry, 1988) (Gibson and Barclay, 1989).

Willis and Moslow (1994 a, b) interpreted siliciclastic and bioclastic sandstone facies of the mid-late Triassic (Ladinian-Carnian) Halfway and Doig Formations as a parasequence set deposited in high-stand and transgressive systems tracts as a product of cyclic shallow marine sedimentation in a continental shelf setting. Lastly, Davies et al., (1994) have identified two sequences within the Montney in West-Central Alberta. The two sequences have been dated and can be correlated closely to two global eustatic sea level

events. Thus, they should occur throughout the Western Canada Sedimentary Basin, depending on local structure. The lower Montney Sequence (Sequence 1) ranges in age from early Griesbachian to Dienerian while the Upper Montney Sequence (Sequence 2) is dated tentatively as Smithian (See Figure 13b).

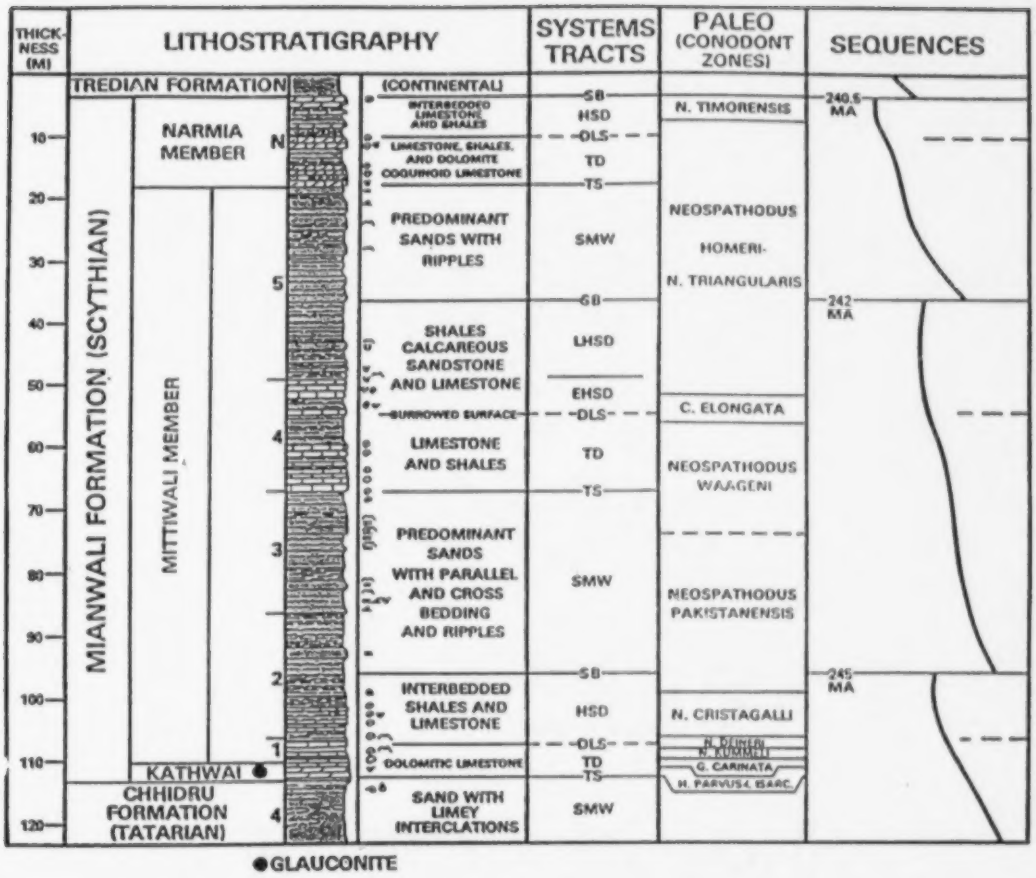


Figure 11: Lithostratigraphic, paleontologic, and sequence-stratigraphic data of the Scythian (Lower Triassic) section at Nammel Gorge, Salt Range, Pakistan. Lithostratigraphy after Nakazwa and others (1985) and paleontological zonation after Matsuda (1985). EHSD: Early highstand deposits; LHDS: Late highstand deposits. (After Haq et al, 1988).

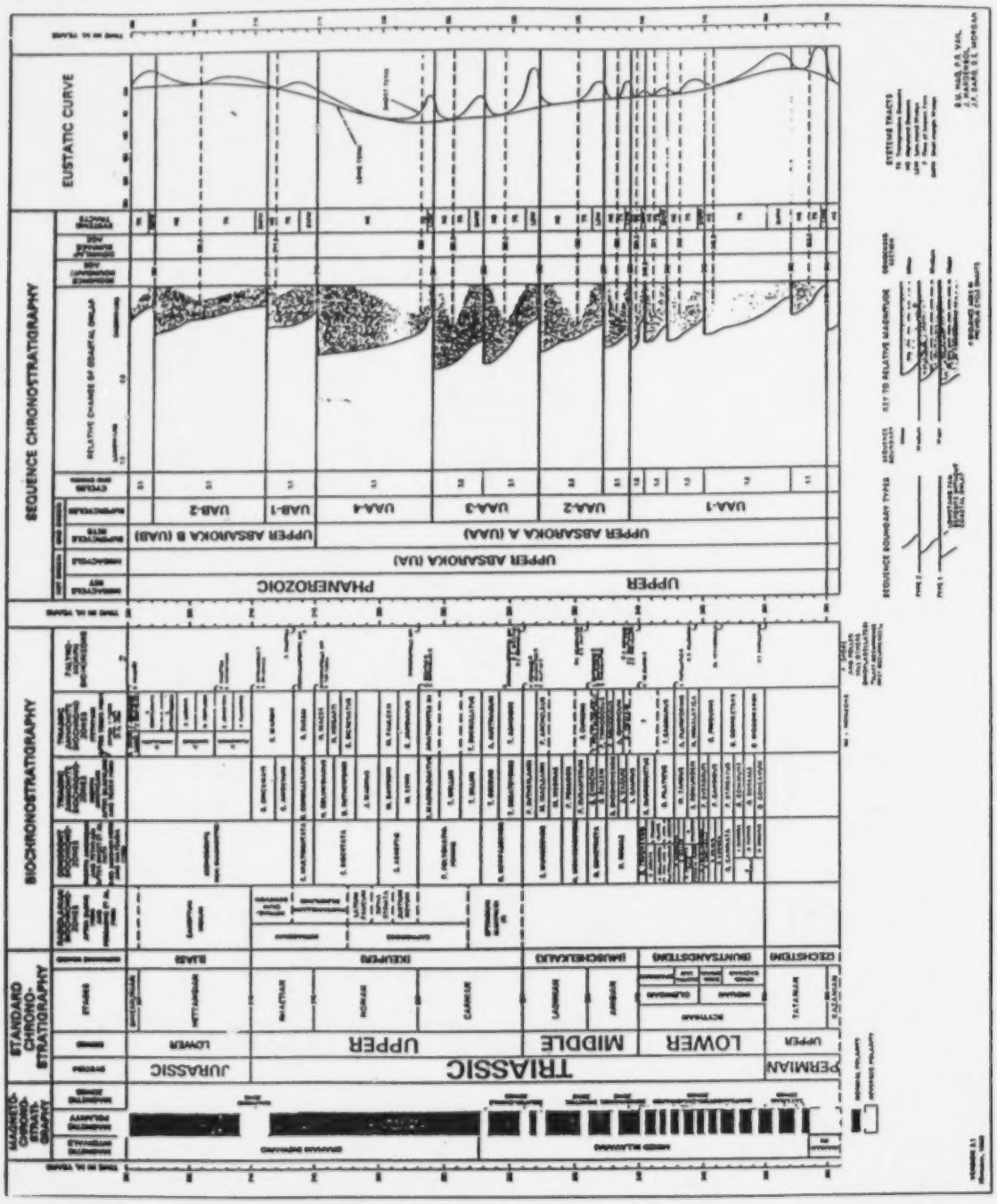


Figure 12: Triassic chronostratigraphic and eustatic-cycle chart (After Haq et al, 1988). The Triassic magnetic-polarity reversal model is synthesized from available paleomagnetic data and is provisional, subject to modification in the future as new data are accumulated from this interval.

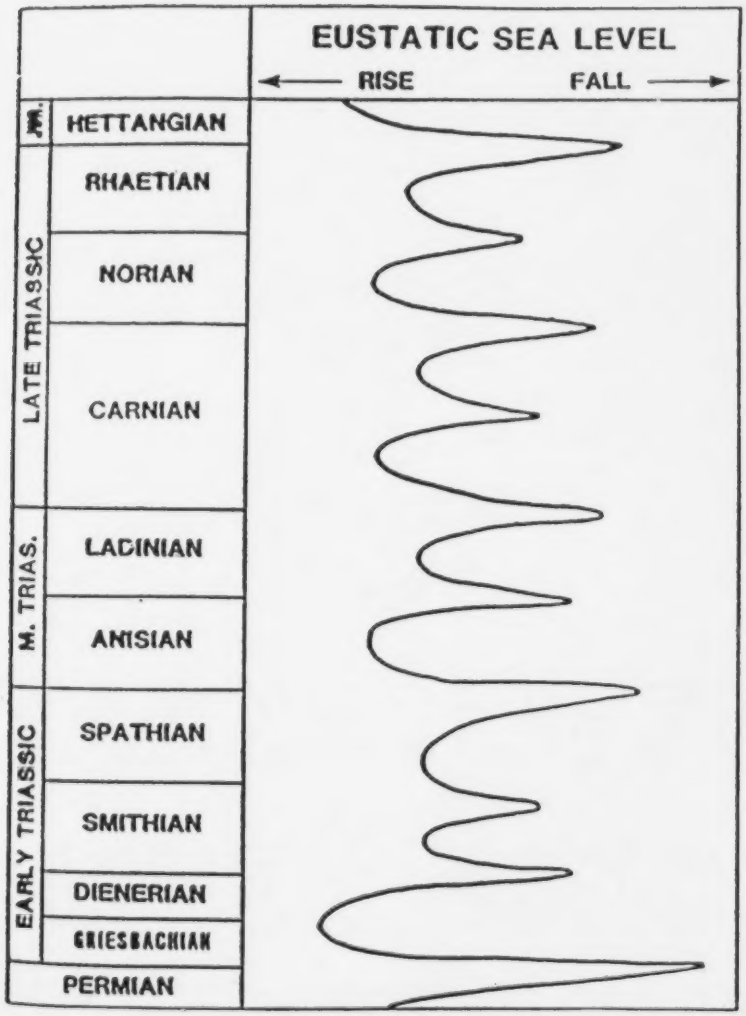


Figure 13a: Eustatic sea-level curve for the Triassic based on Canadian Artic T-R cycles and the proposed relationship between T-R cycles and eustatic sea-level changes. Magnitude of changes are relative. (After Embry, 1988).

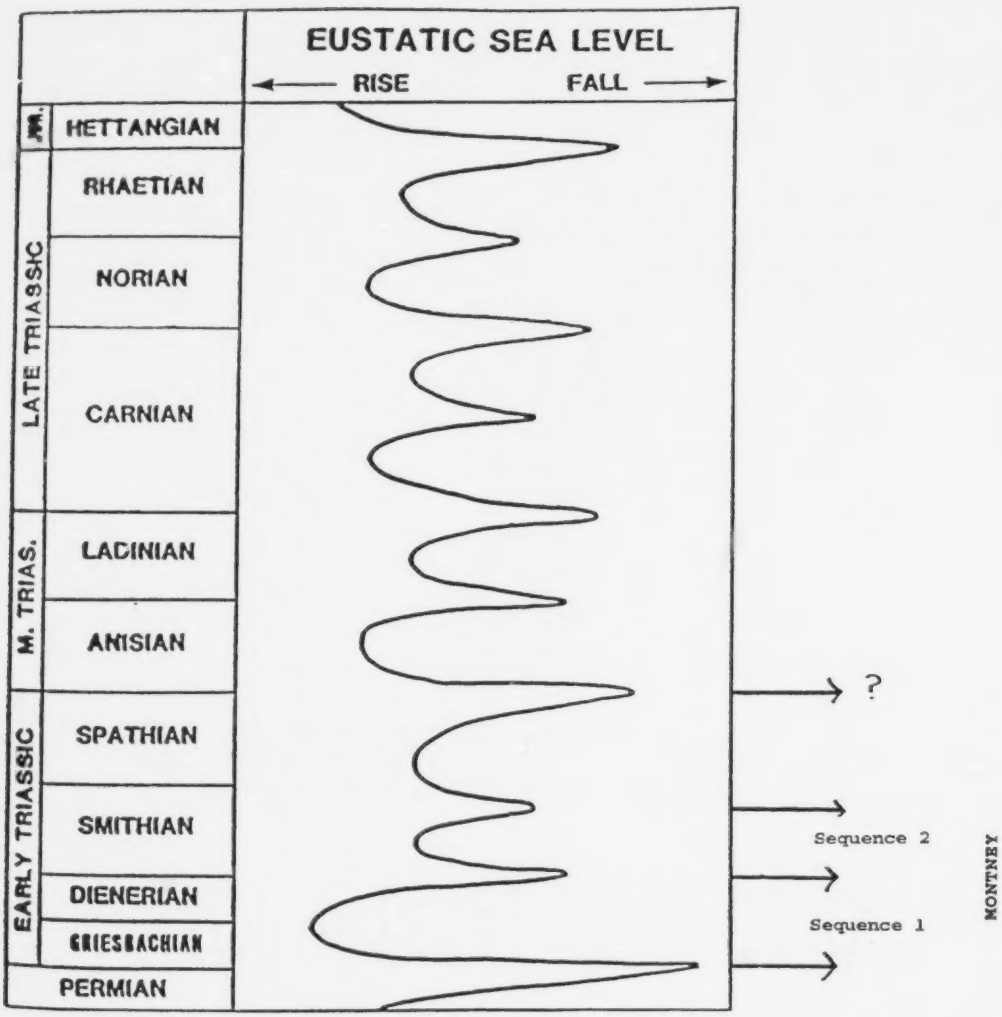


Figure 13b: Correlation of Montney of subsurface WCSB with sea-level-driven transgressive-regressive cycles of the Triassic of the Sverdurp Basin, Canadian Artic (From Embry, 1988) (After Davies et al, 1994).

5 STRUCTURE IN THE STURGEON LAKE AREA

The Triassic lithostratigraphic formations maintain a regional northwest-southeast depositional strike (Figure 1 and 14) and the rate of dip increases sharply nearer the foothills (Hunt and Ratcliffe, 1959). The Peace River Arch, which was maintained as a strong positive feature throughout Devonian time, subsided during Triassic time, causing the sediments to accumulate over the location of the Arch. There appears to have been a positive feature in the area of Fort Nelson which may have restricted Triassic deposition in that area (Hunt and Ratcliffe, 1959) (Figure 14).

Structural contours for the top of the Montney Formation indicate a relative uniform monoclinal structure dipping south-west with a minor flattening over producing regions (Sitzler, 1992). A more localized approach about the structure pattern of the Montney Formation on the Sturgeon Lake South Triassic Pools was made by Miall (1976). He indicates that these pools are located at the edge of the Devonian Woodbend Reef Field (Figure 15). The A pool is situated over the updip edge of the reef, and structural contours drawn on the Triassic-Nordegg contact (Figure 16) suggest that in this area the regional south westward dip flattens, due to a drape effect over the reef edge (Miall, 1976). Drilling density north of the A pool is insufficient to demonstrate whether or not there is closure. Therefore, it is unknown to what extent structure has influenced the formation of the hydrocarbon trap. For the B pool, contours clearly indicate a drape effect in the form of a structural nose. Although there is no closure, Miall (1976) has suggested that structure has influenced the shape of the pool. Miall (1976) also suggests the influence of the Woodbend reef during deposition of the Toad-Grayling in the distribution of facies and porous and non-porous units. Figure 17 and 18 are structural maps of the top of the Permian Belloy Formation and of the top of the Montney Formation in the Sturgeon Lake area. They look almost identical, indicating that during the Early Triassic time, tectonism was not a factor controlling the sedimentation in the Sturgeon Lake Area.

The structure on the top of the Permian Belloy and the Triassic Montney formations reveals a southwest dipping monocline. At the 860m Triassic contour and 952m Permian contour, there is a pronounced break in slope and the monocline becomes steeper. In the center of the area there is a structural nose dipping and closing southwest. There is no closure to the north-east, and the nose becomes slightly narrower up section. The structural trend seem to have had an influence on hydrocarbon trapping because Triassic oil wells are distributed along the structural nose and flatter area of the structure (Figure 18) (Sitlzer, 1992; Miall, 1976).

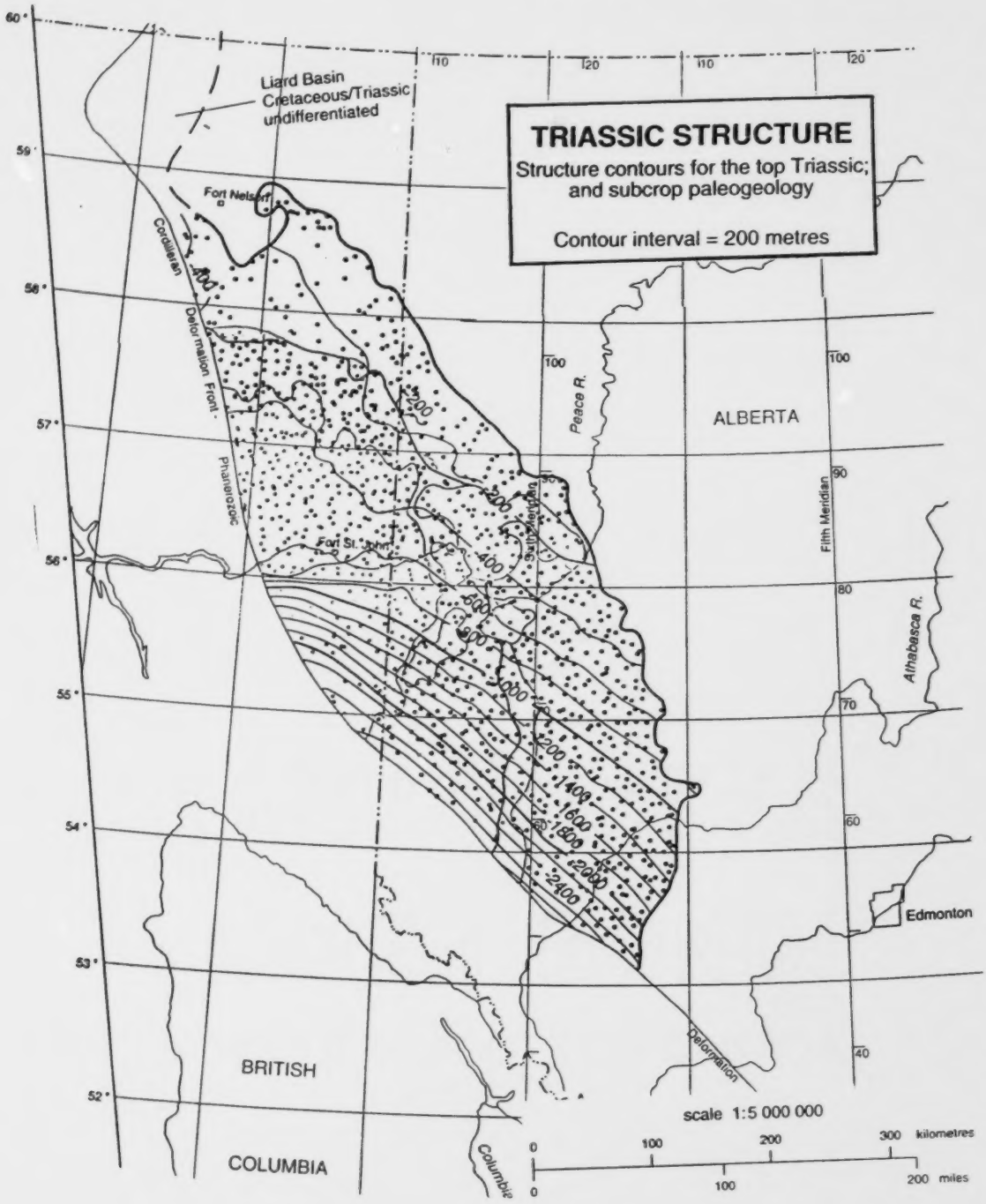


Figure 14: Regional structural contours for the top Triassic. Dots indicate Triassic subcrop (After Edwards et al, 1994).

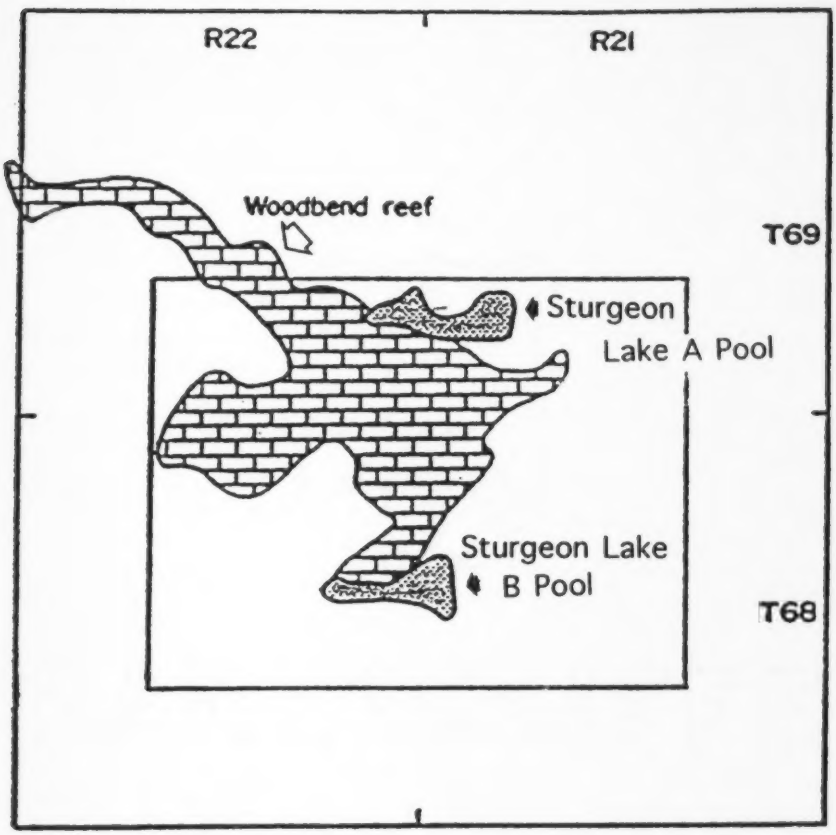


Figure 15: Location of the Devonian (Woodbend) and Triassic oil pools at Sturgeon Lake South (After Miall, 1976).

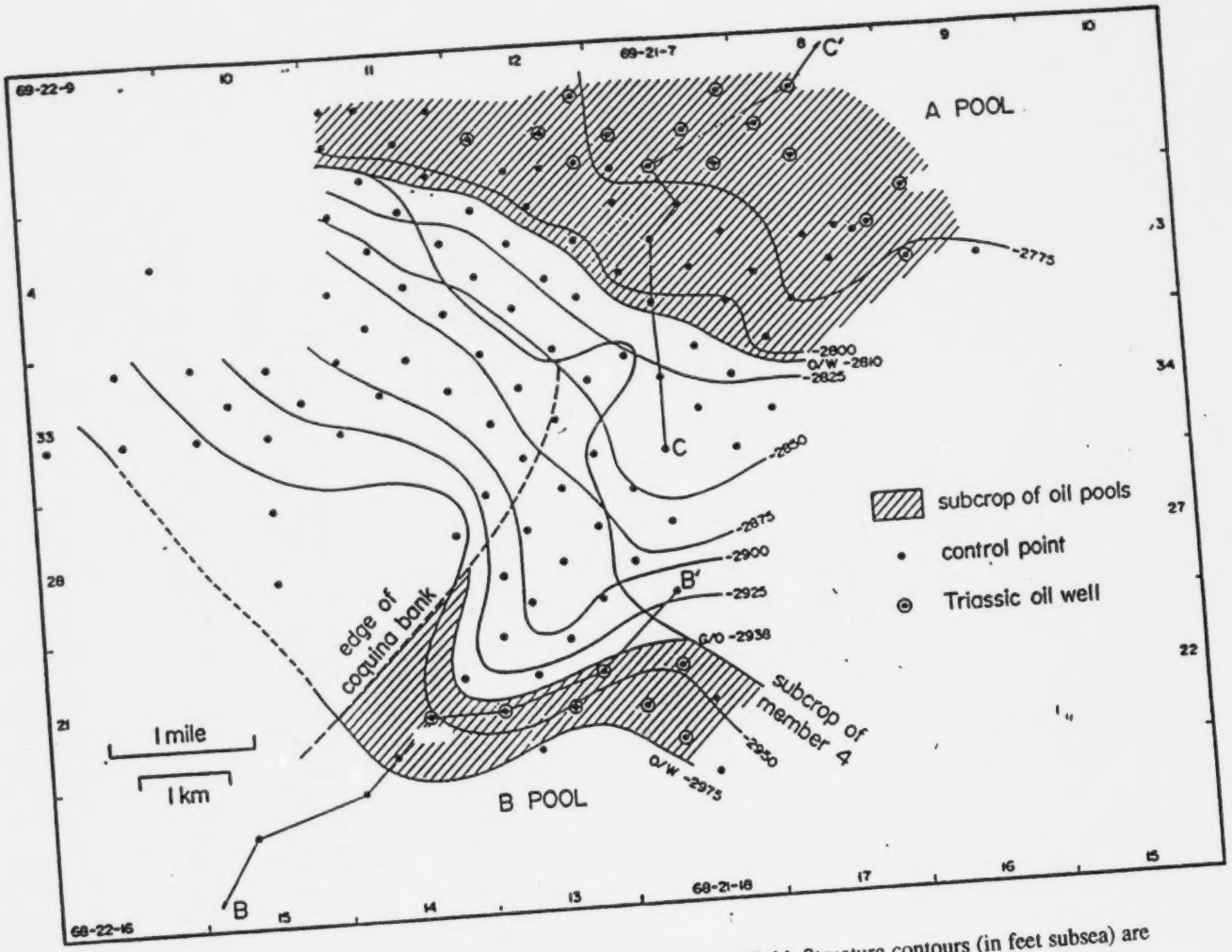


Figure 16: Geology of the Sturgeon Lake South Triassic oil field. Structure contours (in feet subsea) are drawn on the Toad-Grayling-Nordegg unconformity. (After Miall, 1976).

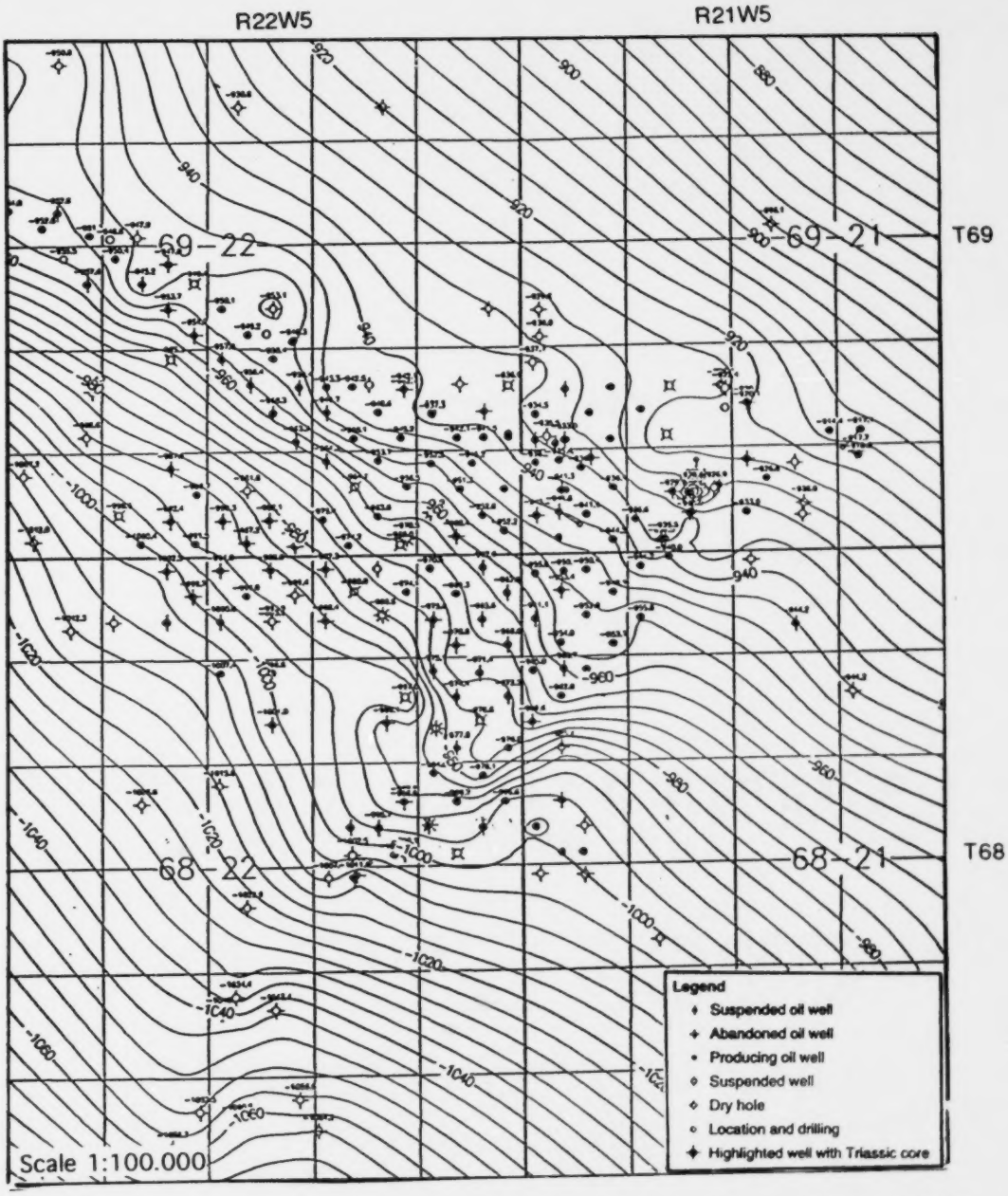


Figure 17: Structure of the top of the Belloy Formation in the Sturgeon Lake area. (Map provided by Unocal Canada Limited).

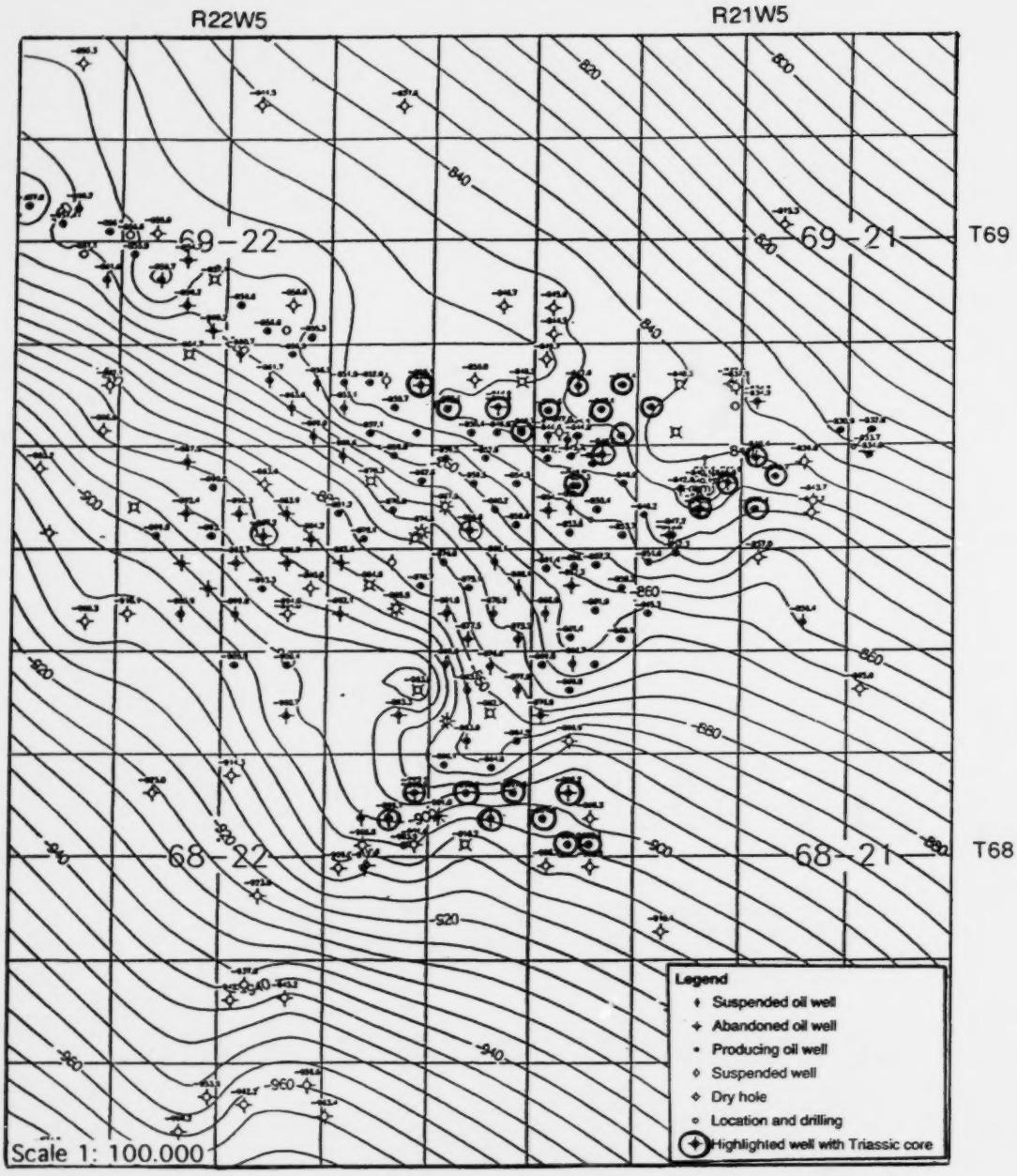


Figure 18: Structure of the top of the Triassic in the Sturgeon Lake area. Circled wells represent Triassic oil wells (Map provided by Unocal Canada Limited).

Miall (1976) suggested that the Woodbend reef trend influenced deposition of the Toad/Grayling and the distribution of the facies and porous and non porous members (Figure 15). The structural contours do not reflect a paleotopographic high over the Woodbend Devonian Reef, nor is there evidence of post Devonian reef collapse. Unfortunately cored wells are not homogeneously distributed throughout the field so it is not possible to establish the influence of the Woodbend reef in the facies distribution.

6 SEDIMENTARY FACIES

The Montney Formation within the study area has been divided into eleven sedimentary facies which are summarized in Table 1. Each facies was established on the basis of lithology, textures, physical and biological sedimentary structures. In this chapter, each facies is defined in detail and given an informal name followed by an environmental interpretation. The definitions of the facies are based on the objective descriptions of the core.

6.1 FACIES A: Bioturbated Siltstone

Facies A is a bioturbated siltstone to very-fine silty sandstone. It is poorly sorted and it has a distinctive mottled texture (plate 1). Bounding surfaces are sharp. The thickness of the facies ranges from 0.05m to 1.2m. Facies A is normally interbedded with Facies B, C, and D. The prevalent feature of Facies A is its mottled appearance which is a product of animal activity (Reineck, 1975). Bioturbation structures (Richter, 1952) cause destruction or deformation of primary sedimentary structures. It is likely that in Facies A primary sedimentary structures were obliterated by bioturbation. Bioturbated beds may occur in many different settings but most likely occur under conditions of slow or discontinuous deposition where there is little or no redistribution of sediments by waves or current action (Conybeare and Crook, 1968). When Facies A is associated with Facies B or C, it has been interpreted as the result of a fair weather period absent from storm or wave activity, thus allowing the organisms to rework the sediments. Occasionally, as in wells 15-18-68-21W5, 11-19-68-21W5 and 7-23-68-22W5, Facies A indicates a deepening event and possibly a marine flooding surface (MFS).

6.2 FACIES B: Interlaminated Burrowed Silty Shales And Very Fine Sandstone

Facies B is an interlaminated sandstone and shaly siltstones to silty shales and generally located in the basal part of the individual facies associations within the study area. Sandstone beds are very fine grained and range from 0.2cm to 10cm in thickness. The

Table 1: Cont.

FACIES	LITHOLOGY	THICKNESS	BEDDING FEATURES	PHYSICAL SEDIMENTARY STRUCTURES	BIOGENIC SEDIMENTARY STRUCTURES	DEPOSITIONAL ENVIRONMENT
NT BIOCLASTIC SANDSTONE	Normally graded bioclastic sandstone or wackestone	0.06m-0.7m	Basal contacts: Erosive and sharp planar Top contacts: sharp	Normally graded	Non-burrowed	Proximal Tempestites (Lower to Middle Shoreface)
BR BRECCIA	Sedimentary breccia; Dolomitized intraclastS in a quartz-silt rich dolomitized mudstone	0.12m-0.6m	Basal contacts Erosive and sharp Upper contact gradational	Normally graded	Non-burrowed	Gravity flows (Middle to Upper shoreface)
WPB MOLDICBRACHIOPOD WACKESTONE-PACKSTONE DOLOWACKE	Brachiopod dolowackstone-packestone	0.03m-0.5m	Basal contacts: Transitional, Sharp-planar, Sharp-erosive. Upper contacts: Sharp-planar	Inversely graded Amalgamated beds, Ocasionally trough cross bedded or plane bedded	Non-burrowed	Middle to Upper Shoreface (Shoreface ridges on shoals)

Table 1: Cont.

FACIES	LITHOLOGY	THICKNESS	BEDDING FEATURES	PHYSICAL SEDIMENTARY STRUCTURES	BIOGENIC SEDIMENTARY STRUCTURES	DEPOSITIONAL ENVIRONMENT
D WELL SORTED MASSIVE SANDSTONE	Well sorted massive appearing sandstone	0.1m-2.0m	Sharp, planar Contacts	Massive appearing dewatering structures	Non-burrowed, Ocasionally *Diplocrateriоum* *Teichichnus*	Sedimentary Gravity Flows Turbidites or fluidized flows and/ or Tempestites
E DOLOMITIC SANDSTONE	Poorly sorted dolomitic mottled siltstone to sandstone	0.1m-2.0m	Transtional or sharp, planar basal contacts, truncated by Nordegg Formation	None observed	Mottled texture (no discernable traces)	Proximal Lower Shoreface
F LAMINATED SILTY SHALE	Dark grey shale or silty shale	0.025m-0.15m	Sharp planar contacts	Parallel laminated to massive appearing	Non-burrowed	Offshore
DM DOLOMUDSTONE	Light grey dolomudstone	0.09m-1.5m	Sharp basal contact Upper contact sharp or transitional	Massive appearing	Occasional burrows *Allychnus* *Skolithos*	Lower Shoreface

Table 1: Summary of Sedimentary Facies in the Montney Formation

FACIES	LITHOLOGY	THICKNESS	BEDDING FEATURES	PHYSICAL SEDIMENTARY STRUCTURES	BIOGENIC SEDIMENTARY STRUCUTES	DEPOSITIONAL ENVIRONMENT
A BIOTURBATED SILTSTONE	Siltstone to very fine Sandstone	0.05 to 1.2m	Sharp planar bounding surfaces	None observed	Bioturbated *Skolithos* *Planolites* *Cylindricnus*	Offshore transition
B BURROWED SILTY SHALE AND SANDSTONE	Interlaminated silty shale and very fine sandstone	Individual beds: mm-10cm Whole unit: 0.18m-4.6m	Sharp based sandstone beds	Horizontal and lenticular laminae Normally graded beds. Ripples	Burrowed *Rosselia* *Cylindricnus* *Teichichnus* *Planolites* *Skolithos* *Palaeophycus* *Ophimorpha* *Chondrites* Escape burrows	Proximal Offshore Transition
C RIPPLE LAMINATED SANDSTONE AND SILTSTONE	Very fine sandstone with subordinate shaly siltstone	0.15m-7.32m	Sharp based sandstone beds Whole unit: transitional truncated by the Nordegg Formation	Low relief ripple laminations Amalgamated Sandstone beds	Burrowed *Rosselia* *Cylindricnus* *Teichichnus* *Planolites* *Palaeophycus* *Rhizocoralium* *Skolithos*	Distal Lower Shoreface

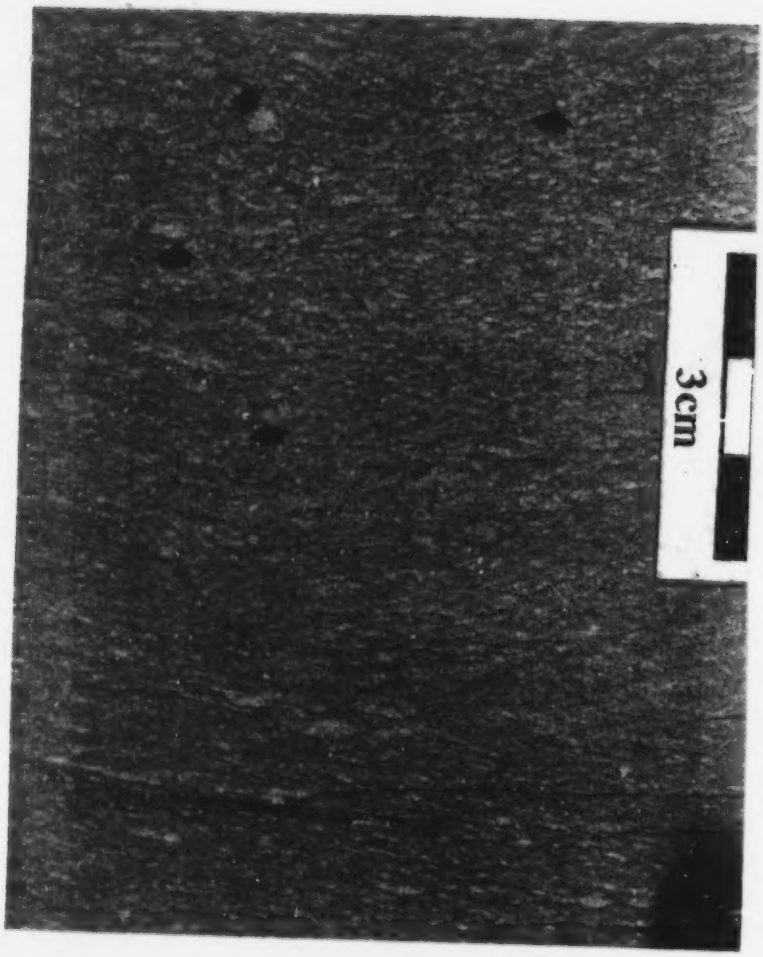


Plate 1: Bioturbated sandstone with mottled texture (Facies A). Arrow indicates individual burrow traces (*Planolites*). Well 5-19-68-21W5 Sturgeon Lake B Pool. Depth: 5108'6" (1572.6m).

sandstone beds have sharp, erosional or loaded bases and upper surfaces that are gradational and/or rippled (Plate 2). Truncated beds, also a common feature, reflect episodic sedimentation possibly as distal tempestites (Snedden, 1985). Fragments of shell valves can be found at the base of some sandstone beds. The beds may be normally graded, contain undulating to parallel internal laminations, and ripple cross-laminations Physical sedimentary structures are scarce.

Sandstones with similar characteristics have been described by Johnson and Hayes (1967), Reineck and Singh (1971), Baldwin (1986) and Walker and Plint (1992) and interpreted as being deposited between storm and fair weather wave base. The sandstone beds of Facies B (45% to 65%) are interpreted as storm deposits (Tempestites) interlaminated with burrowed shaly siltstone to silty shales (55% to 35% of Facies B). The thickness of the silty shales may range from 0.2cm to 10cm. The trace fossil assemblage present in this facies consists of *Cylindricum/ Rosselia*, *Teichichnus* (Plate 3), 'Zigzagus' *Teichichnus* (Plate 4), *Skolithos* , *Palaeophycus*, cf. *Ophiomorpha* , cf. *Helminthopsis* , *Chondrites* and some undefined escape burrows. The trace fossil assemblage is in general low diverse and the traces are vertical to oblique (Plate 4 and 3), and cut through several layers of sediment (Plates 3 and 4). The latter feature indicates the organisms that were living at the time of deposition capable of adapting to environmental changes by readjusting their burrow behavior (Saunders, Personal Communication, 1994). The ichnological suite may be regarded as a low diverse *Cruziana* Ichnofacies with some elements of *Skolithos* Ichnofacies such as *Skolithos* and *Ophiomorpha*. *Cruziana* Ichnofacies is present from the Lower Shoreface to the Upper Offshore and mixture with *Skolithos* Ichnofacies is possible in the shalower settings like the Offshore transition and Lower Shoreface (MacEachern and Pemberton 1992). Low diversity is one of the charactieristics to recognize brackish water assemblages (Ranger and Pemberton, 1988). Moslow and Pemberton (1988) used the low diversity *Cruziana* Ichnofacies assemblages as a criteria to define distal delta front facies due to the difficulties to differentiate shoreface sedimentary facies from those of a delta front. The trace fossil characteristics indicate conditions of episodic sedimentation in a low energy environment where there was a well established, low diverse community able to live in a stressed environment (Saunders, Personal Communication 1994). Thus, the silty shales likely represent the post-storm fair-weather mud deposition where the dominant process is suspension sedimentation (Johnson and Baldwin, 1986). The sedimentary process for each bed-set seems to be well summarized in Figure 19, which is an idealized storm-fair weather sequence. Facies B is interpreted as being deposited in the proximal part of the offshore transition or may be the distal delta front.

Plate 2: Lateral variation of laminae thickness (A) and gently undulate or wavy ripple top surface (B) in an interlamination of silty shales (darker) and very fine sandstones. Facies B. Well 14-6-69-21W5. Depth: 4968'-4967'6" (1514.3m-1514.1m). Sturgeon Lake A pool.

Plate 3: Burrowed Facies B *Teichichnus* (A). Well 3-23-68-22W5. Depth: 5168'-5167' (1575.2m-1574.9m).Sturgeon Lake B pool.

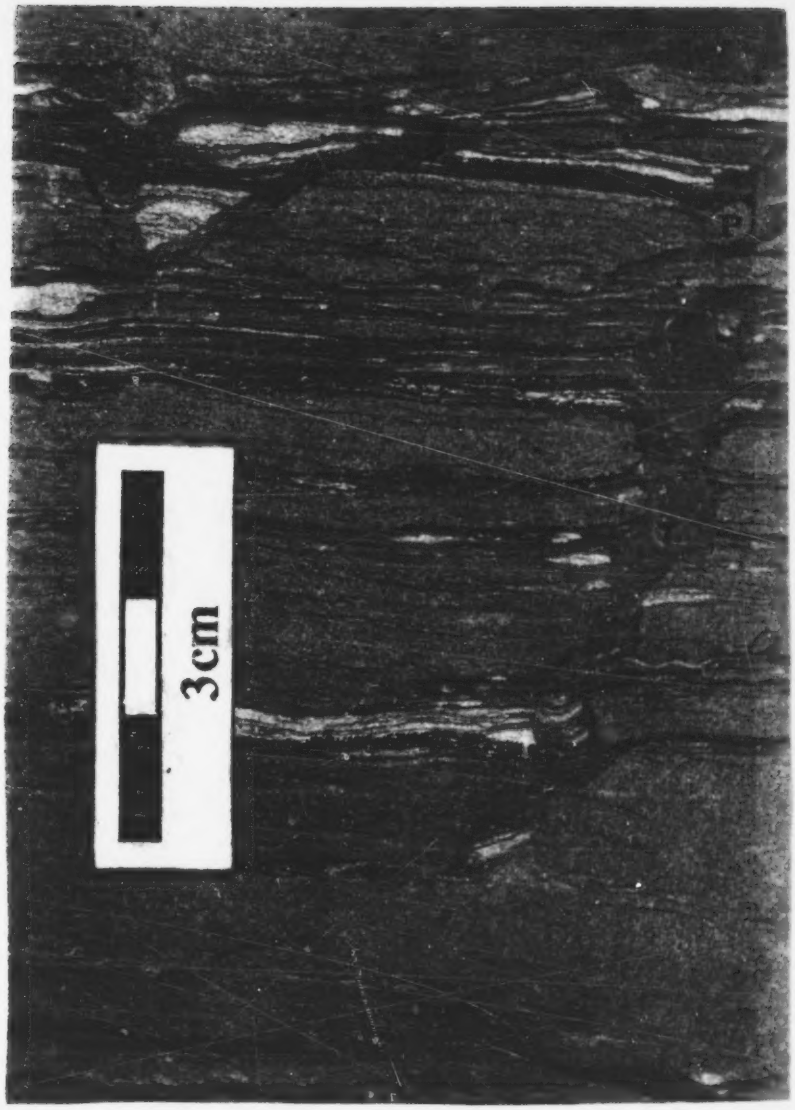


Plate 4: *'Zigzagus' Teichichnus* (T) and *Palaeophycus* (P), Facies B.
Well 3-19-68-21W5. Depth: 5158'4" (1572.3m). Sturgeon Lake B pool.

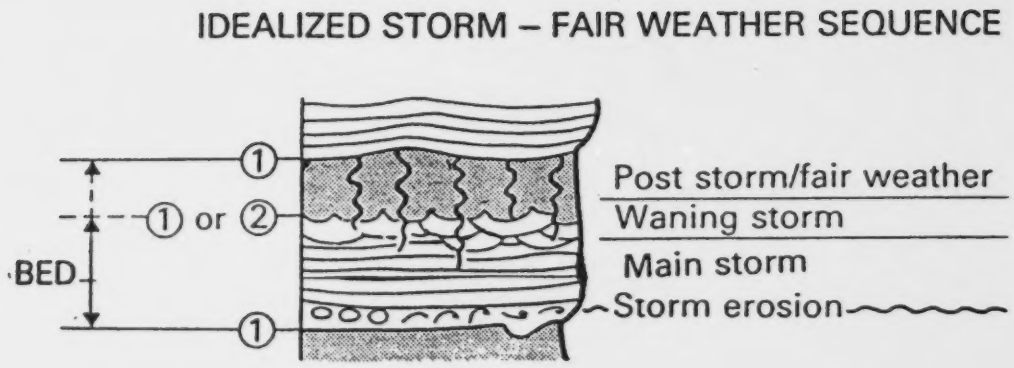


Figure 19. An idealized storm-fair weather (=hummocky) sequence with interpretations of the origin of the different components. Numbers indicate the hierarchical order of the surfaces. (After Reading, 1986).

In the offshore transition zone, sandy layers as well as muddy layers are equally represented (Reineck and Singh, 1975). In practice, the base of the shoreface can be defined where interbedded sandstones and mudstones pass upward into relatively clean sandstones (Walker and Plint, 1992) (see figure 20). Wave dominated shelves are controlled by seasonal fluctuations in wave and current intensity, with active sediment transport restricted to intermittent storms where fine-grained sediment and small-scale bedforms predominate (Johnson and Baldwin, 1986).
All the afore-mentioned characteristics of Facies B suggests that such a facies has accumulated in the proximal part of the offshore transition zone or the distal delta front just below the fair weather wave base, in a wave-and-storm-dominated shelf.

6.3 FACIES C: Parallel to Laterally Discontinuous Low Relief Ripple Laminated Sandstone with Subordinate Shaly Siltstone

Facies C consists of a ripple laminated sandstone with shaly laminae that decrease in abundance upwards. Also in the upper portion of this facies, the shale laminae are more planar-parallel and the sandstone fraction displays a subtle increase in grain size. These features indicate an increase in the energy level of deposition. Facies C is commonly present in the upper part of individual facies associations and is transitional with Facies B below and with Facies E and D above. In many cases, the upper part of Facies C is truncated by the Nordegg Formation. Sharp contacts with other facies are found less commonly . The whole unit can be considerably thick, reaching 7.32m where sandstone consists of 70 to 90% and shale consists of 10 to 30%. Sandstones are very-fine to fine-grained, similar to Facies B. However, Facies C sandstone beds are thicker, varying from 0.2cm to 2.5cm. Low relief ripple laminations are common and frequently the laminae are disrupted (Plate 5). It is also common to find lateral variations in laminae thickness.

Bed truncations (Plate 6) and sharp contacts at the base of laminae are observed. Lags of phosphatic shell fragments, possibly lingulid brachiopods, were observed in well 5-19-68-21W5 (Plate 7) along with laminae of heavy minerals. Symmetrical ripples (Plate 8) and trough and planar cross lamination may be present in the upper part of Facies C. Facies C is burrowed, but in general trace fossils are not abundant (<5%). The trace fossil association for this facies consists of *Rosselia, Skolithos, Teichichnus* and lesser quantities of *Palaeophycus, Rhizocorallium* and *Planolites*. Some undefined escape traces are also present. The trace fossil association for Facies C is very similar although less diverse to the one present in Facies B suggesting an increase in the energy level of the

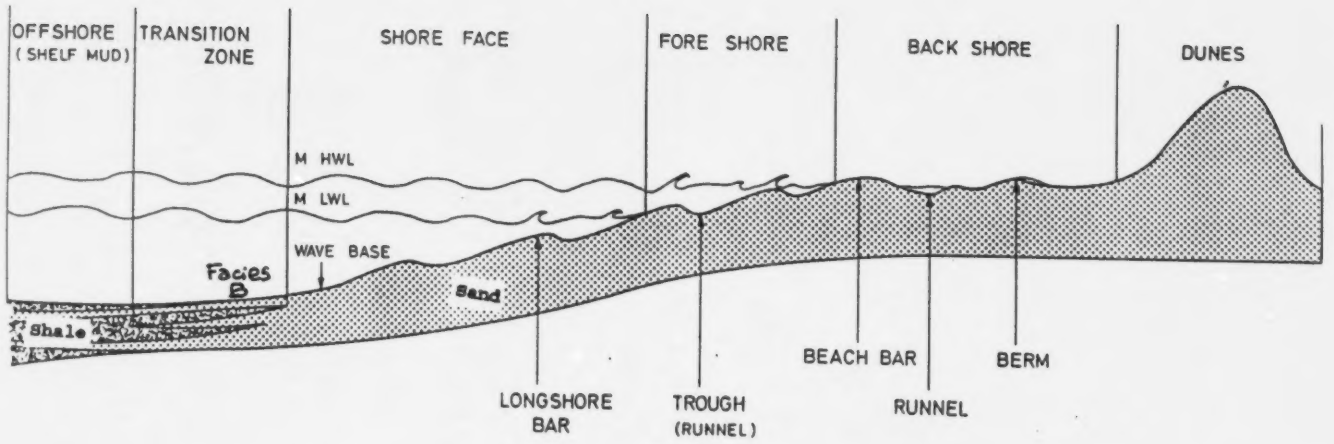


Figure 20: Schematic representation of the terminology of the various geomorphic units of the shoreface and inner shelf. (After Reineck, 1975). Notice the sand/shale relation in the different geomorphic units.

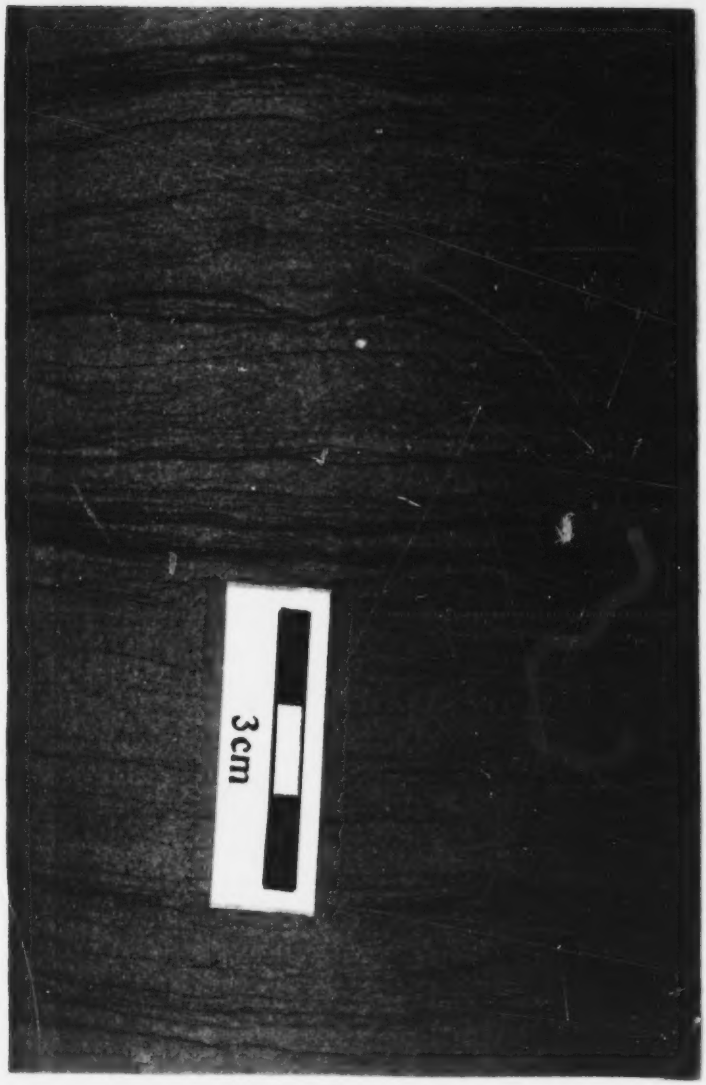


Plate 5: Low relief ripple laminated sandstone (Facies C).
A) Discontinous laminae
B) Lateral variation in laminae thickness
C) Ripples laminated surface in sandstone
Well 7-26-68-21W5. Depth: 5233'6" (1595.12m). Sturgeon Lake B pool.

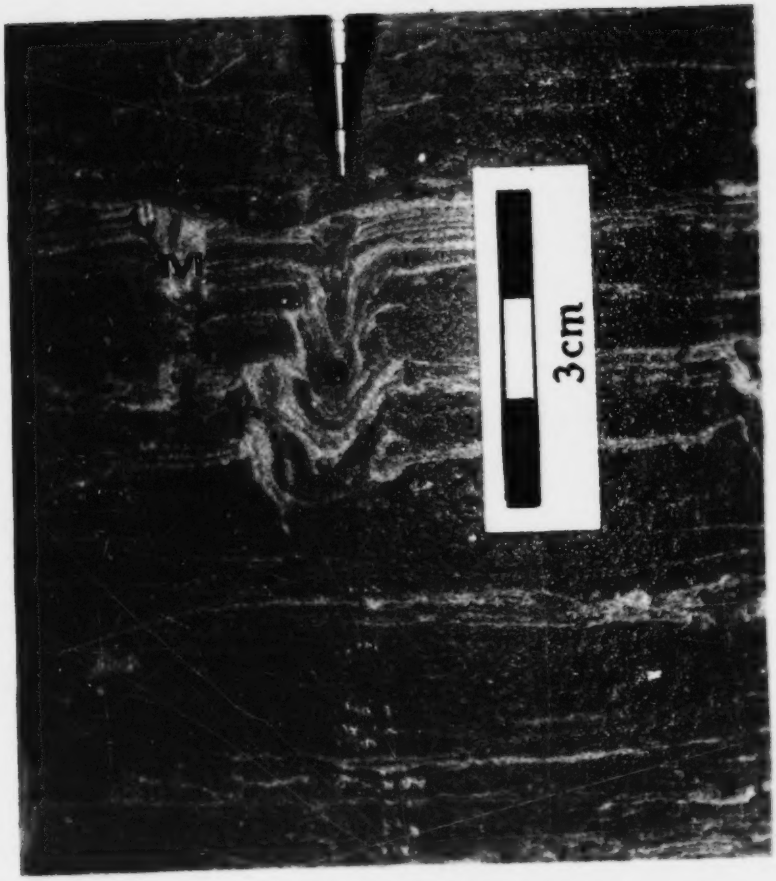


Plate 6: Abrupt bounding surface (arrow) truncating bed with *Bergaueria* (B) and *Monocraterion* (M) in Facies C. Well 15-6-69-21W5. Depth: 4923'4" (1500.6m). Sturgeon Lake A pool.

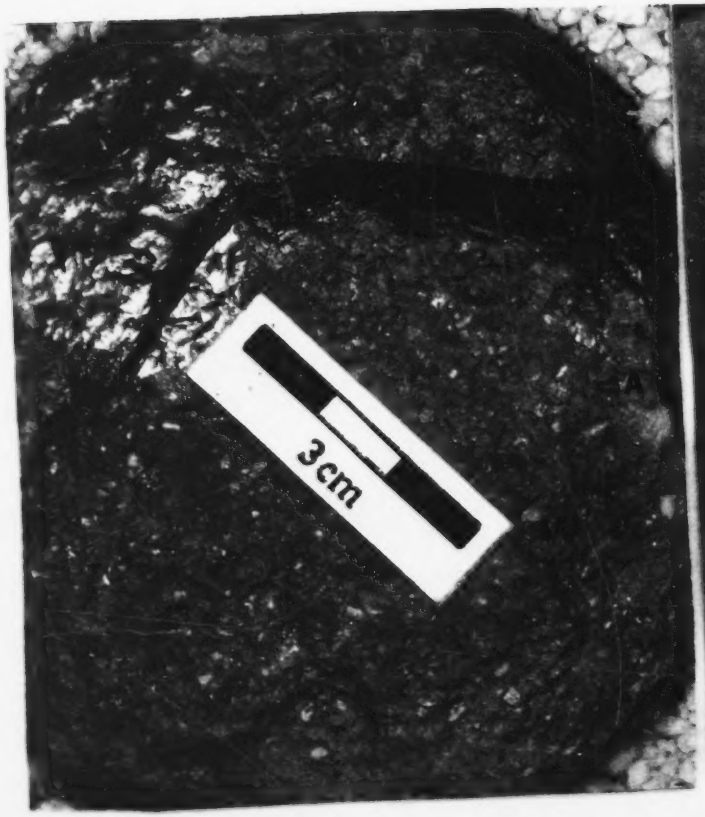


Plate 7: Fragments of valves of lingulid brachiopods (A), at the base of a sandstone bed. Well 5-19-68-21W5. Depth: 5116' (1559.4m). Sturgeon Lake B pool.

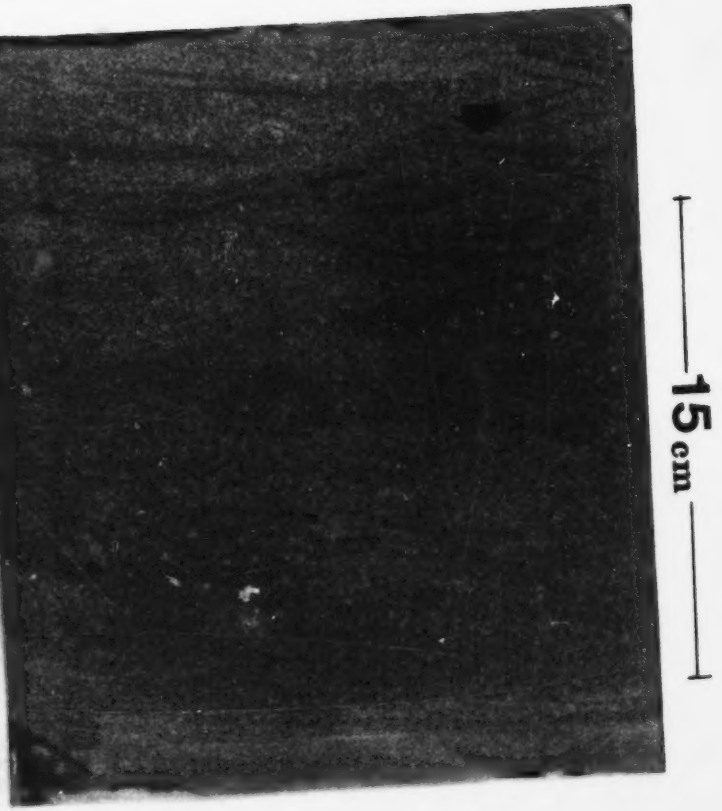


Plate 8: Symmetrical ripples (Arrow) in Facies C. Well 5-7-69-21W5. Depth:4874' (1485.6m). Sturgeon Lake A pool.

setting. Therefore, as in Facies B, the trace fossil does infer processes of very rapid sedimentation in a low energy environment (see discussion of Facies B). One unique and distinctive feature in Facies C is a concentration of several *Cylindricnus/Rosselia* traces on a surface near the top of the unit. Four to five traces on the same level surface have been observed in conventional cores. Normally the traces cut through many sandstone and siltstone laminae developing 'readjustment structures' (Plate 9) trying to reach the equilibrium with the new conditions of the environment (Saunders, Personal Communication). Modern organisms that construct similar types of traces might live four to five, or even ten years, suggesting again that Facies C, at least in some portions, was deposited rapidly. The density of traces per burrowed surface also suggests that these were surfaces full of deposit feeding organisms. Polychaetes are likely responsible for the trace (*Rosselia)* . Their density, and near unimodal diversity such that they were extremely well adapted to the prevailing environmental conditions.

Facies C sandstones are commonly dolomite cemented especially at the top of the unit close to the contact with the Nordegg Formation. Cement distribution is patchy and white in color, giving the facies a mottled texture (Plate 10). The sandstone/shaly-siltstone ratio and physical sedimentary structures of these sandstone beds indicate traction current transport processes and less influence of deposition from suspension. Also, the ripple lamination, as a main feature of this facies, infer current processes, likely combined flows above mean fairweather base in the shoreface (Elliot, 1986). In a Miocene wave-dominated-sequence in southern Spain the offshore-transition facies is comprised of mudstone with thin storm-generated silty sandstone beds, while the lower shoreface facies is comprised of an alternation of wave-ripple lamination and flat lamination interpreted as the product of fairweather and storm shoaling-wave processes respectively (Elliot, 1986). In conclusion, evidence suggests that Facies C was deposited in the distal lower shoreface or a distal delta front of a wave-storm dominated shelf where the predominant process was oscillatory (wave) currents and geostrophic storm-generated flows.

6.3.1 Petrologic Description: Facies C

Based on the sandstone classification of Pettijohn *et al.*, (1973) (Figure 21) Facies C is an interlaminated quartz-arenite, quartzwacke and hybrid sandstone. The laminae of quartz arenite constitute 40 to 70% of this facies. The main mineralogy is quartz with minor quantities of plagioclase, chert, microline, metamorphic fragments, tourmaline, zircon, muscovite, pyrite, and glauconite (Appendix B). The quartz grains are angular to

Plate 9: Surface deposit feeding with at least 6 *Rosselia/Cylindricnus* traces (R). The traces cut through several layers of sandstones (S) and silty shales (M) which are interlaminated.
A: Well 5-7-69-21W5. Depth: 4874'-72' (1485.6m-21.9m)
B: Well 3-8-69-21W5. Depth: 4925' (1501.1m)

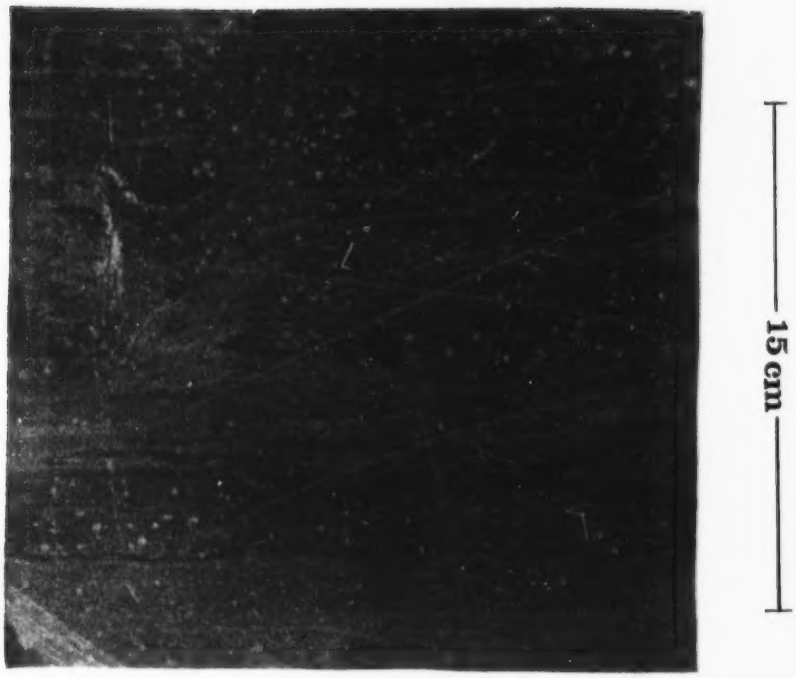


Plate 10: Dolomite cement (Spar dolomite) (arrows) in Facies C. Well 5-6-69-21W5. Depth: 4917'6" (1498.9m). Sturgeon Lake A pool.

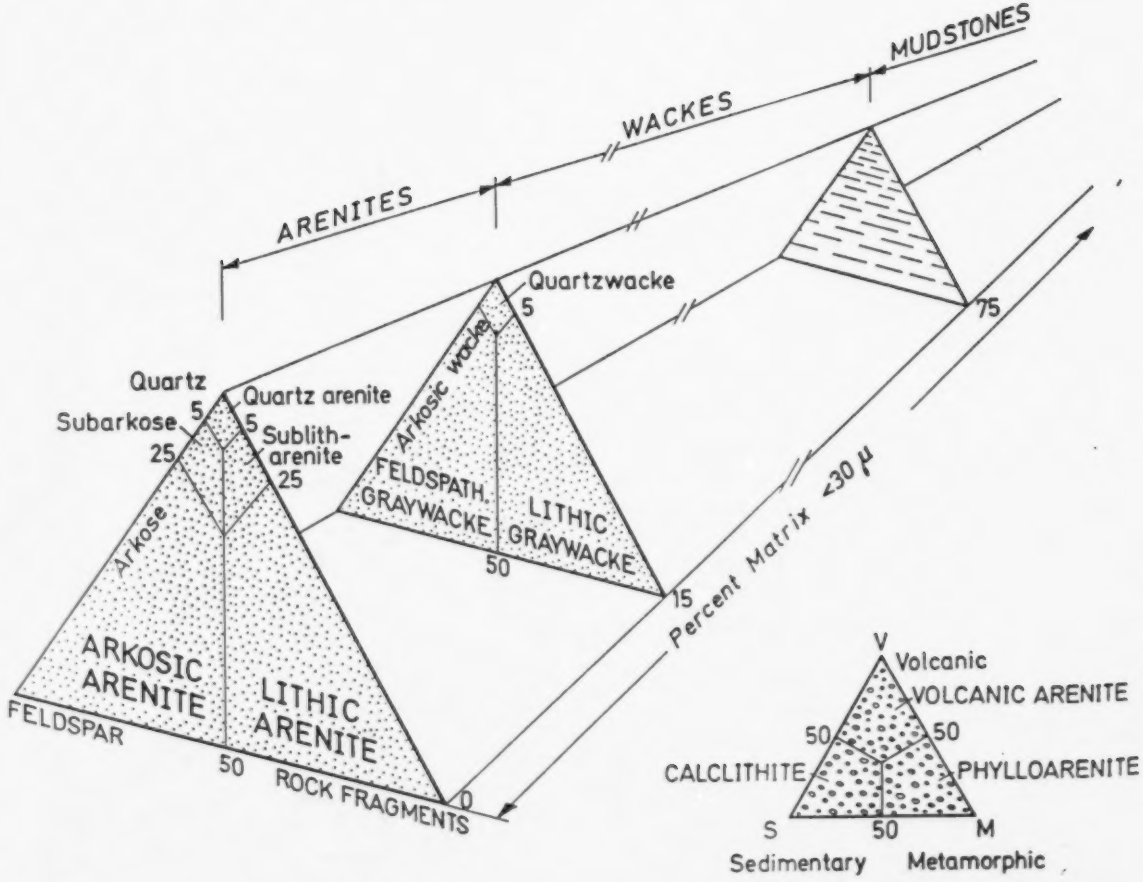


Figure 21. Classification of terrigenous sandstones (Modified from Dott, 1964; after Pettijohn et al (1973)).

subrounded and the sorting is generally moderate. The quartzwacke and hybrid sandstone constitute 30 to 60% of the facies. Although the mineralogy of the detrital grains is the same as the quartzarenites, detrital grains are mixed with an argillaceous or an argillaceous-dolomitic matrix. The matrix may constitute 20 to 50% of individual beds.

There are three types of dolomite present in Facies C. The first and the most abundant type (10 to 40%) is small to medium (<100μm) (see Folk (1962) and Figure 22) anhedral dolomite replacing the calcite portion of the original matrix in the hybrid sandstone. The other types of dolomite occur as a void filling. Following the definition of void filling from Sibley and Greg (1987), this term includes cement and dolomite that replaced a precursor cement due to the fact that it is often difficult to distinguish between the two of them. One variety of the void filling dolomite occurs as a clear spar directly comparable to calcite spar. It is pinkish and grey under polarized light and does not stain. The last variety of dolomite occurs as small to medium, euhedral to subhedral, cloudy dolomite. Crystals are homogeneously distributed and constitute 3 to 10%. Dolomite crystals often have cloudy centers and clear rims. The cloudiness arises from the presence of inclusions,which are mineral relics of the $CaCO_3$ precursor (Tucker, 1992). Finally, the porosity of Facies C is mainly primary (interparticle) and may vary between 7 and 35%. The permeability in this unit may vary from 10md to 132md and has an average value of 21md. The aforementioned characteristics surprisingly give this fine grained facies attributes of an excellent reservoir.

6.4 FACIES D: Well-Sorted Massive Sandstone

Facies D is a well sorted, brownish fine grained sandstone. It is massive appearing, with poorly developed graded bedding, and is commonly fractured (Plate 11). The thickness of this facies ranges from 0.1m to 2.0m. The basal and upper boundary surfaces are sharp, and dewatering structures within this facies are commonly observed. Facies D is normally non-burrowed although the trace fossils *Diplocraterion* and *Teichichnus* are rarely observed.

Massive appearing bedding may be a secondary feature produced by extensive bioturbation or cyclic shocking and liquefaction of sediment. It may also be a primary feature of a very rapid deposition from suspension, or from very highly concentrated sediment dispersions in sediment gravity flows (Boggs, 1987). Dewatering structures are indicative of abundant fluid escape during deposition of sandstone, and may also indicate rapid deposition of a large amount of sand from a fluidized flow (Walker, 1983). Massive

A	
Extremely Coarsely Crystalline	>4mm
Very Coarsely Crystalline	1–4mm
Coarsely Crystalline	1–250μm
Medium Crystalline	62–250μm
Finely Crystalline	16–62μm
Very Finely Crystalline	16–4μm
Aphanocrystalline or Cryptocrystalline	1–4μm

B	
Micron–sized	0–10μm
Decimicron–sized	10–100μm
Centimicron–sized	100–1000μm
Millimetre–sized	1–10mm
Centimetre–sized	10–100mm

Figure 22. Terminology for crystal sizes in limestones and dolomites. (A) After Folk (1962). (B) After Friedman (1965). (Taken from Tucker, 1992).

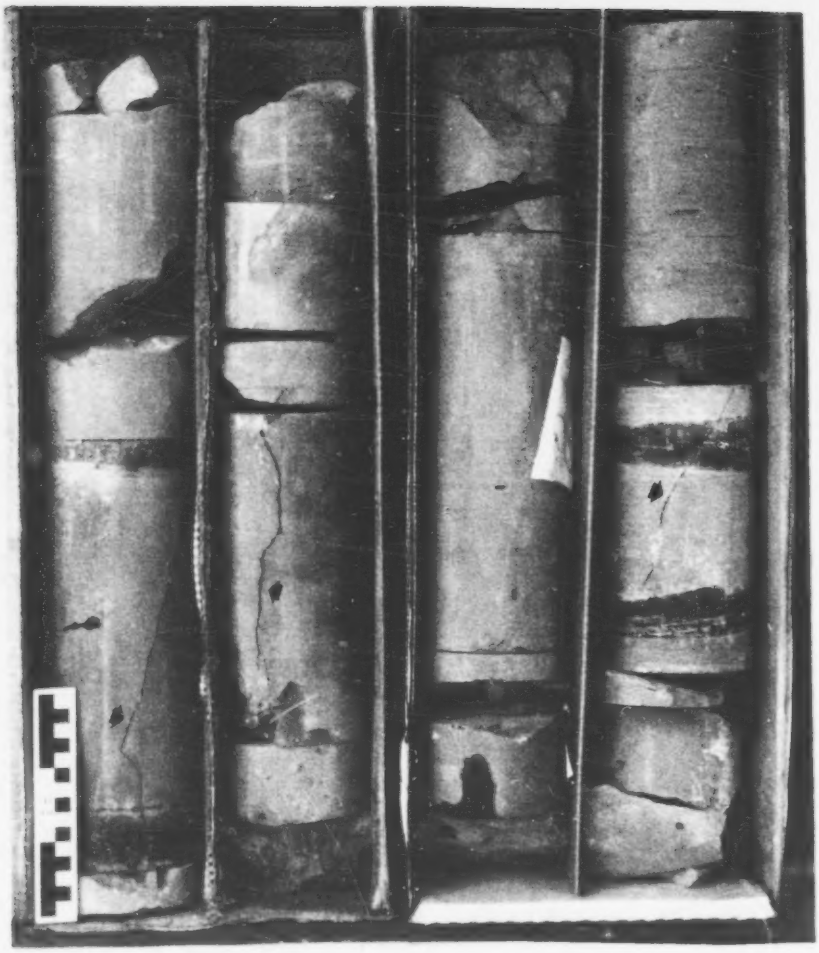


Plate 11: Massive appearing sandstone with open vertical fractures (Arrows) (Facies D). Well 15-6-69-21W5. Depth:4940'-4932' (1506.1m-1503.7m). Scale is in cm.

appearing normally graded beds with sharp bases are common to both tempestites and turbidites (Einsele and Seilacher, 1991) and soft sediment deformation is more common to turbidites than tempestites. On the other hand, bed amalgamation, which also occurs in Facies D, is more common for proximal tempestites than for turbidites (Einsele and Seilacher, 1991). Figures 23 and 24 shows characteristic features of proximal to distal, sandy and muddy tempestites and turbidites, taken from the work done by Einsele and Seilacher (1991) on the distinction between tempestites and turbidites.

Finally, Facies D is distributed irregularly through out the sequence and does not constitute a very extensive body of rock, but its geometry is more continuous along the strike than along the dip. An Isopach map of the reservoir facies of Facies D in Parasequence 5 (Figure 32) is located mainly within a clear elongated narrow body of rock parallel to depositional strike. This latter characteristic is one of the most important reasons that Snedden used in 1992 to preclude the turbidity current hypothesis proposed by Hayes (1967) to explain the mechanism of deposition of storm deposits associated with Hurricane Carla in 1961. Figure 25 is an isopach map of the present day thickness of the Carla sand bed on the Texas continental shelf showing the same along-strike trend found in Facies D.

Facies D, then, may have been deposited by both turbidity current and storm processes. Sedimentology evidence suggests that Facies D sandstones are turbidites of fluidized flows which amy occur on the shoreface as well as on the distal front. The geometry of the deposits, however, as well as their stratigraphic context, seem to indicate that some of these deposits are the product of stronger storm activity in the offshore transition and lower shoreface environment.

6.4.1 Petrologic Descriptions

Facies D is a dolomitic quartz arenite. Its major constituent is quartz with lesser quantities of plagioclase, chert, microcline, metamorphic rock fragments, muscovite, tourmaline, zircon, intraclasts, micritic grains, glauconite and phosphatic shells. Facies D is moderately well sorted. Grains are subangular to subrounded and vary texturally from coarse siltstone to very fine sandstone. Dolomite occurs in 10 to 20% of the facies as replacement and/or as a void filling. Dolomite in Facies C and D has similar characteristics (see petrologic description of Facies C). Porosity in Facies D is interparticle (primary) and range between 5 and 20%. Permeability is variable, ranging from 10 to 37080 md. The highest permeability is related to open vertical fractures, while the lowest values of Kmax are related to the lowest porosity of the facies. Facies D is a significant potential hydrocarbon reservoir and occasionally is oil stained.

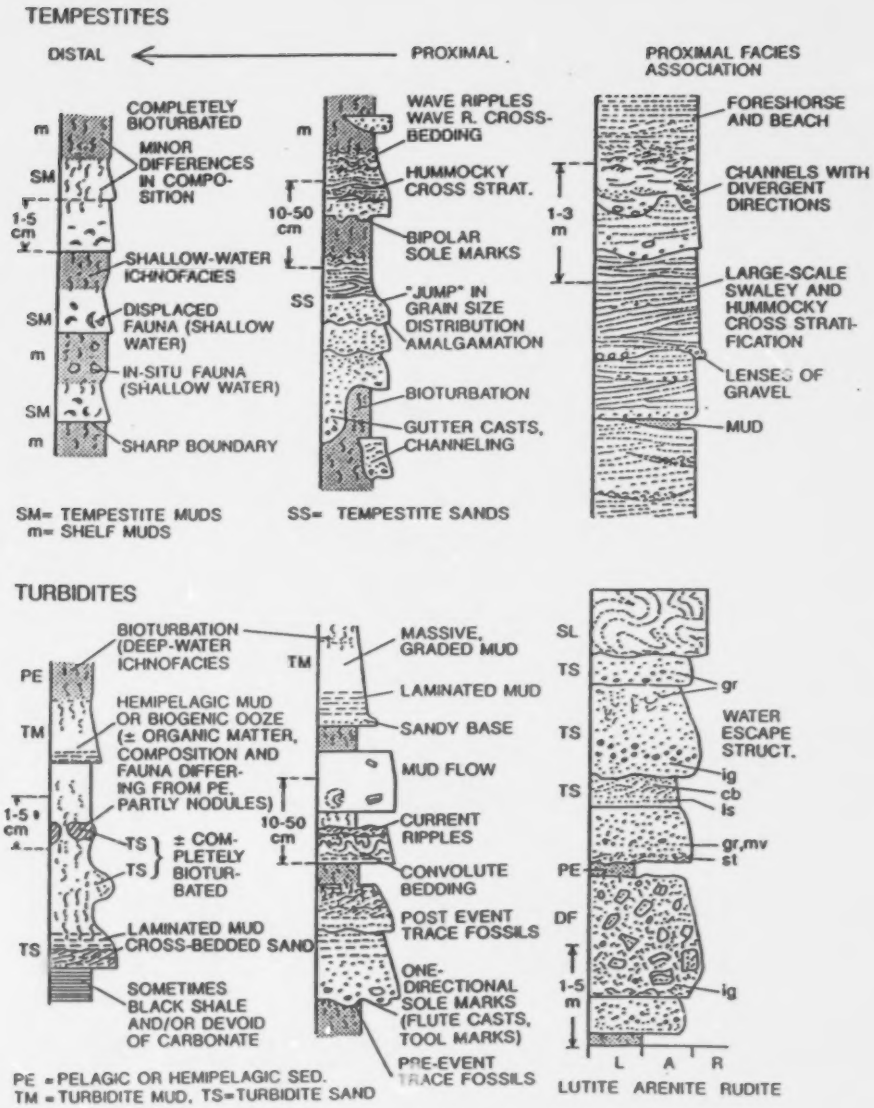


Figure 23. Characteristic features of proximal to distal, sandy and muddy tempestites and turbidites (After Einsele and Seilacher, 1991).

		Tempestites	Turbidites
Sedimentary structures (from top to bottom of bed)	Wave ripples and wave ripple cross lamination	Common (apart from distal types)	Absent
	Current ripples and current ripple bedding	Less common than in turbidites	Common
	Convolute lamination	Rare	Common
	Hummocky cross-stratification	Common	Absent
	Traction carpet with inverse grading	Absent	Common in proximal types
	Nature of sole marks	Often bipolar, pronounced irregular scouring, gutter casts channeling	Uni-directional
Bio-facies	Benthic background community (in muddy intercalations)	Shallow water fauna, differing with substrate consistency	Deep-water fauna, mainly represented by burrows
	Displaced body fossils within event beds	Shallow water species only	Shallow and deep-water species
	Autochthonous post-event fauna and bioturbation	Fauna similar to pre-event fauna (return to background fauna, if substrate is similar)	Episodic colonization by specific fauna preceding return to background conditions
Stratigraphic context	Amalgamation	Very common and pronounced, including "maturation" of sediment	Less common, no maturation effect
	Continuity of single beds	Mostly limited	Often over wide distances
	Thickness of sequence	Limited associated with shallow-water facies	In general great, associated with deep-water facies

Figure 24. Criteria to distinguish sandy tempestites from turbidites (After Einsele and Seilacher, 1991).

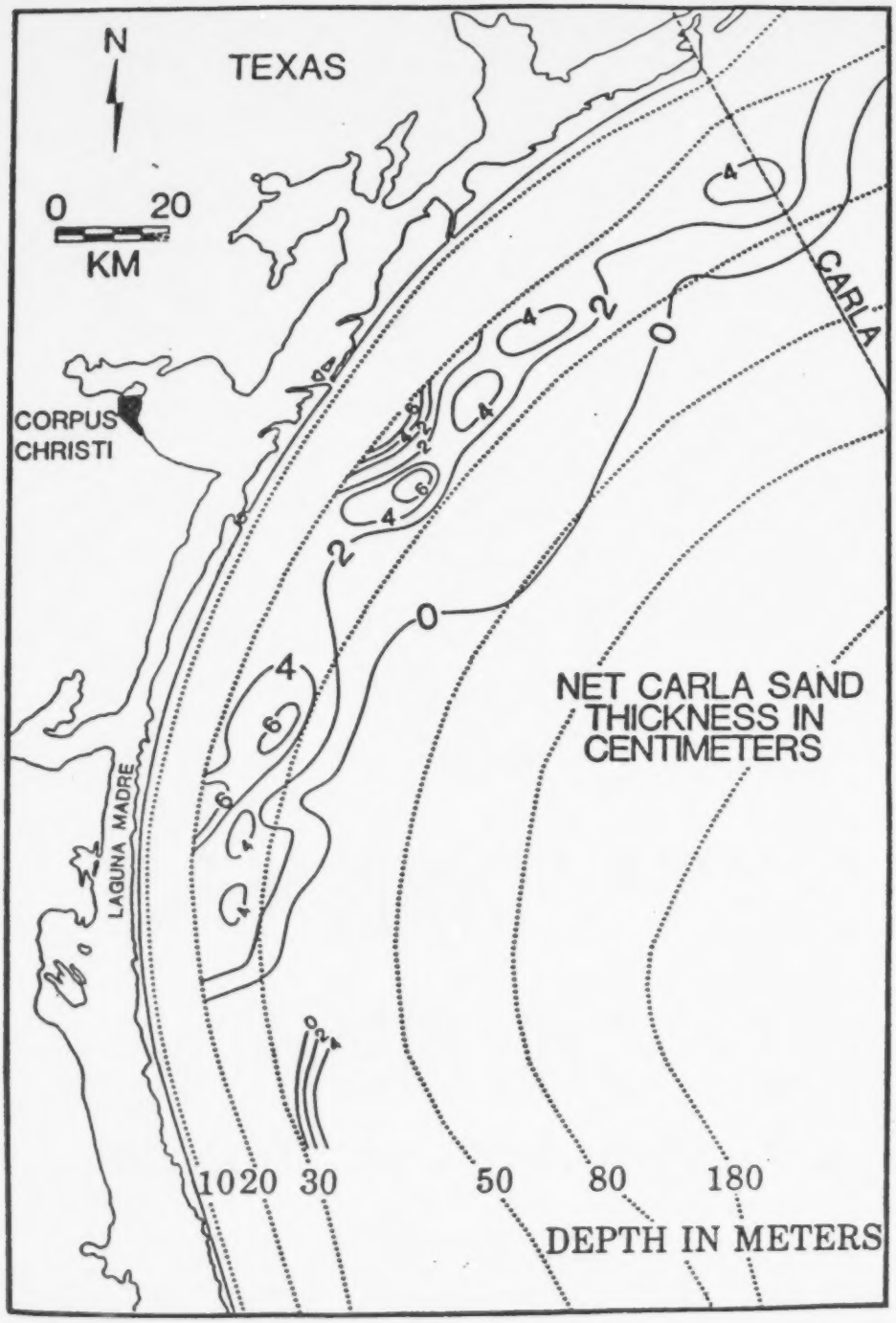


Figure 25. Isopach map of present day thickness of the Carla sand-bed. Contour interval equals 2cm (After Snedden, 1985).

6.5 FACIES E: Poorly Sorted Dolomitic Bioturbated Sandstone

Facies E is a poorly sorted dolomitic siltstone to sandstone with a mottled texture (Plate 12) which seems to be the product of intense burrowing and/or dolomitization. Facies E is restricted entirely to the Sturgeon Lake A pool immediately below the contact with the Nordegg Formation and varies in thickness from 0.1m to 2.0m.

Like Facies A, the most prevalent feature of Facies E is the mottled texture. Facies E is distinguished by its general appearance (type of mottling), thickness, and stratigraphic position. Bioturbation (Richter, 1952) causes destruction or deformation of primary sedimentary structures produced by inorganic agents. Galveston Island, on the Texas coast has a progradational sequence with thick bioturbated sandstones in the upper part of the lower shoreface of a low-wave energy coast (Figure 26) (McCubbin, 1982). Based on the similarities with the Galveston Island sequence, Facies E is interpreted as being deposited in the proximal lower shoreface of a low wave-energy coast where biogeneic processes predominated.

6.5.1 Petrologic Descriptions

Facies E consist of a hybrid sandstone with 40% irregularly distributed micritic matrix and has a distinctive mottled texture which results from bioturbation. The detrital grains consist mainly of quartz with lesser quantities of plagioclase, pyrite and heavy minerals. There is 25% of small to medium (<100μm), crystals of dolomite. Sorting is poor to moderate and porosity is near 0%.

6.6 FACIES F: Dark Grey Shale, Silty Shale

Facies F consists of a dark grey silty shale to shale. The most frequent sedimentary structure present in the siltstone is parallel lamination. Shale beds are massive in appearance. In some cases, a transition between parallel laminated siltstones and massive shale is observed. This facies is non-burrowed. The thickness of this facies ranges from 0.025m to 0.15cm. Facies F is commonly 'interbedded' with Facies B and in some cases with Facies C. The basal and upper contacts of Facies F are generally sharp, although transitional contacts are observed. Facies F reflects deposition from suspension in the distal to proximal offshore environment (Walker and Plint, 1992; Reading, 1980).

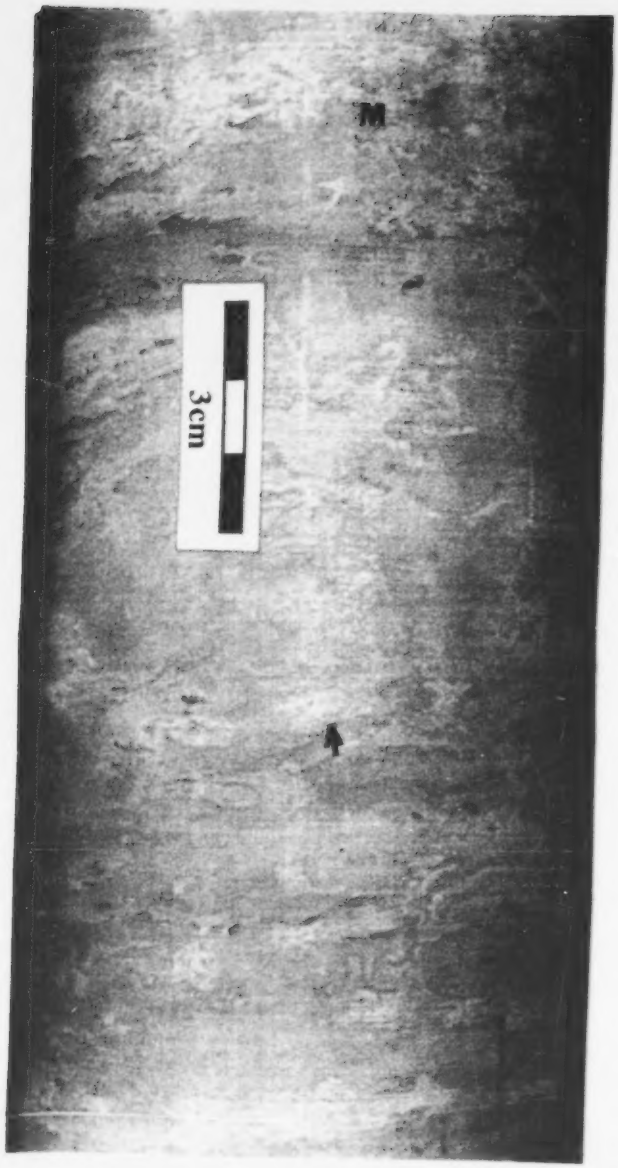


Plate 12: Poorly sorted dolomitic bioturbated sandstone. Arrows indicates dolomite patches.. (M) Mottled texture. Well 9-11-69-22W5. Depth: 4942' (1506.7m). Sturgeon Lake A.

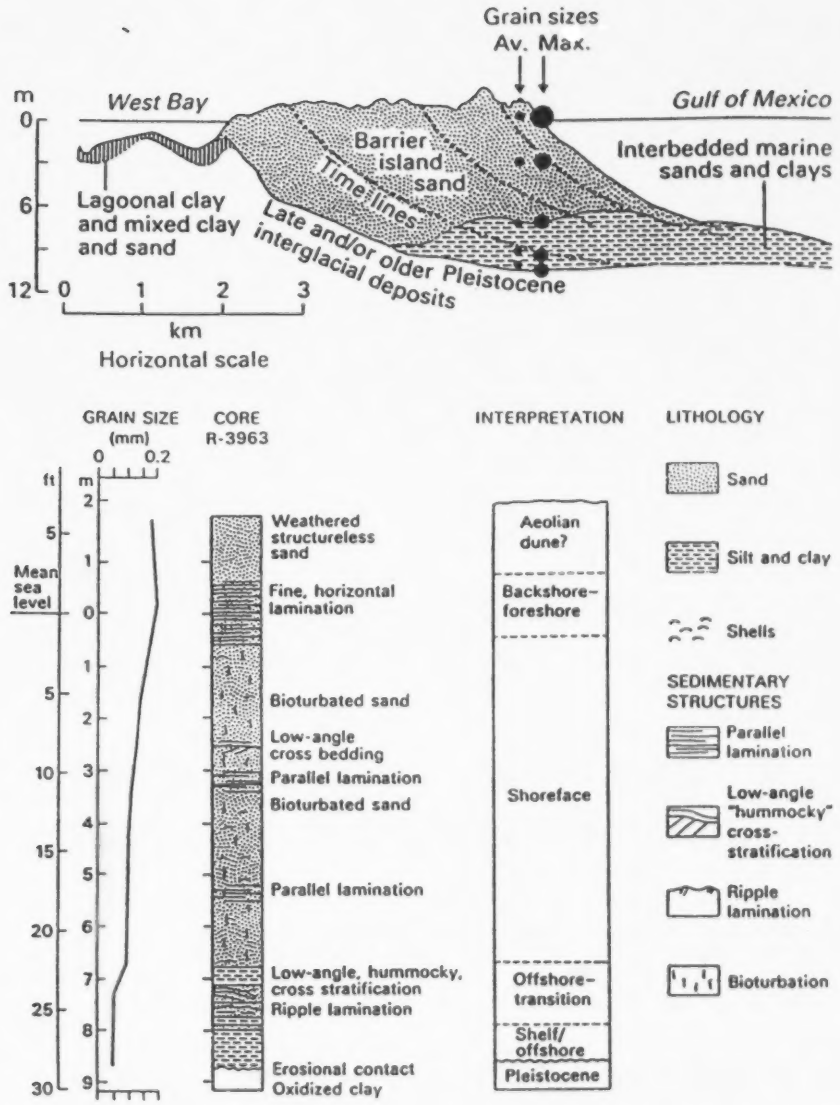


Figure 26. Comparison of the beach-to-offshore facies sequence and thickness from a low-wave-energy coast (Galveston Island) with that inferred for a high-wave-energy coast (Oxnard-Ventura area) (Taken from McCubbin, 1982)

In wells 15-4-69-21W5, 7-23-68-22W5, 3-23-68-22W5, 9-24-68-22W5 and 3-24-68-22W5 Facies F is also cited with a flooding event, the base of which is interpreted as a Marine Flooding Surface (MFS), and thus a parasequence boundary.

6.7 FACIES DM: Light Grey Dolomudstone

Facies DM consists of a light grey dolomitic mudstone. It is mixed with isolated grains of silt and very fine sand. Occasionally lingulid brachiopods and glauconite grains are present. Sorting is moderate to poor. Facies DM is massive in appearance, however in a few cases it is parallel laminated. Stylolites and small fractures are associated with this unit. Facies DM is occasionally burrowed with trace fossils that include *Altichnus* (a variety of *Rosselia*) (G. Pemberton, Personal Communication) and *Skolithos*. *Altichnus* traces can be very abundant (Plate 13). The thickness of Facies DM ranges from 0.09m to 1.5m with a mean thickness of 0.15m. This facies is only present in the Sturgeon Lake B pool and normally occurs interbedded with Facies WPB at the base of the carbonate bioclastic parasequence. Occasionally near the top, this facies seems to be intraclasts instead of real beds due to the very irregular geometry, but the diameter of core is not big enough to observe the lateral extension of this facies. Facies DM has a sharp basal contact. Upper contacts are sharp or transitional.

Facies DM may be interpreted as a suspension deposit. However, other evidences such as poor sorting, and burrowing suggest that Facies DM was deposited and then reworked by burrowing organisms. In the standard facies belts proposed by Wilson (1975), limesilt and bioclastic wackestones and packstone may coexist between the storm wave base and the fair weather wave base (*i.e.* lower shoreface).

6.7.1 Petrologic Descriptions

Facies DM is a dolomudstone. It can be massive or parallel laminated. The mineralogy is mainly dolomite with 1 to 3% quartz, 0 to 4% phosphatic shells and grains, and 0 to 4% opaque minerals. The dolomite is anhedral and small and it is most likely due to replacement of the matrix.

Microscopically the contacts between Facies DM and WPB appears very sharp, irregular, stylolitic and pyritized.

Plate 13: *Altichnus* (arrows) in Facies DM. Well 3-23-68-22W5. Depth: 5151'-5152' (1570.0m-1570.3m). Sturgeon Lake B pool.

6.8 FACIES NT: Normally Graded Bioclastic Sandstone

Facies NT consists of brownish normally graded, bioclastic coarse-to-fine-grained sandstone (Plate 14). Occasionally the lithology is more carbonate than clastic and the facies is technically wackestone. Facies NT contains a large concentration of reworked skeletal material which appears to be mainly lingulid brachiopods and bivalve pelecypods. Most of the carbonate shells are dissolved giving this facies excellent moldic porosity. Facies NT also has vuggy porosity, which increases the overall porosity of the unit. This unit in many cases is associated with fractures (Plate 15). Permeability for this unit is excellent, ranging from 86md to 532md, and it is commonly oil stained (Plate 15).

Facies NT has a thickness that ranges from 0.06m to 0.7m. Ocasionally beds are amalgamated reaching thickness of 1.3m (well 7-26-68-21W5). Basal contacts are erosive and sharp and the top contact is usually sharp. Tucker (1992) characterized deposit with similar features as proximal storm beds (Tempestites).

Evidence of storm processes is provided by the concentration of reworked skeletal material (Reading, 1986). Storm layers reflect two events:

1. The storm peak which is represented by a basal shell bed, locally derived intraclasts and oriented shells; and
2. The overlying waning phase with features like graded beds (Reading, 1976; Tucker, 1992).

These characteristics as well as its vertical association with the other facies indicates that Facies NT were storm deposits in the lower shoreface.

6.9 FACIES BR: Sedimentary Breccia

This facies occurs only in three wells 3-23-68-22W5, 7-27-68-22W5 in the Sturgeon Lake B pool and 9-4-69-22W5 at the west end of the Sturgeon Lake A pool. Facies BR is a sedimentary breccia (Plate 16) with large angular and subrounded intraclasts (up to 10cm). The intraclasts are dolomitized and occur in a dark grey detrital quartz-silt rich dolomitized mudstone. The unit grades quickly to a dolomitic siltstone which can be parallel laminated. The contacts are sharp or erosive at the base of the unit. The upper contact, in most cases is sharp or occasionally gradational. The thickness of Facies BR varies from 0.12 to 0.6m.

Al-Shaiels and Lynch (1993) defined 'sedimentary breccia' as a carbonate rudstones having rounded or angular clasts, that are formed by erosion of an exposed

Plate 14: Normally graded bioclastic coarse to fine sandstone (Facies NT). Molds of brachiopods (M) and Intraclasts (I). Well 3-19-68-21W5. Depth: 5129' (1563m). Sturgeon Lake B pool.

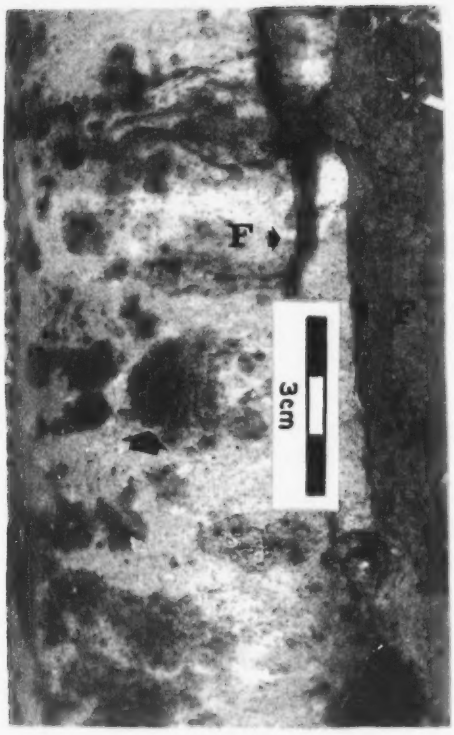


Plate 15: Facies NT fractured (F) and oil stain (arrow).
Well 3-23-68-22W5. Depth: 5133'-5132' (1563m-1564.2m). Sturgeon Lake B pool.

Plate 16: Sedimentary breccia (Facies BR) with dolomitized large, rounded intraclasts (I) and a dark grey detrital quartz silt rich dolomitized matrix (M). Well 3-23-68-22W5. Depth: 5137'4"-5137'9" (1565.96m-1565.99m). Sturgeon Lake B pool.

carbonate terrain adjacent to, or possibly within, the environment of deposition. This type of deposit is not specifically related to Karstification but does infer superficial erosion during the time of sedimentation. Facies BR is interbedded with Facies WPB which has been interpreted to be deposited in the middle to upper shoreface. Facies BR may be interpreted as a gravity flow deposit in the middle to upper shoreface.

6.9.1 Petrologic Description

Facies BR consists of rounded to subrounded intraclasts, poorly sorted and surrounded by a dolomitic matrix. The intraclasts range from 0.1cm to 3.0cm and consists of dolomite with 4% of moderately sorted quartz grains and 5% of lingulid brachiopods and bivalve pelecypods. Some of the shells are silicified.

The matrix is mainly dolomite with some calcite, it contains shells and peloids. The contacts between the intraclasts and the matrix is in some cases stylolitic, and very sharp. Facies BR has microporosity and the dark color of the matrix is the result of oil stain.

6.10 FACIES WPB: Inversely Graded Brachiopod Wackestone-Packstone

Facies WPB is a brachiopod Wackestone-Packstone and is only present in the uppermost part of the Sturgeon Lake B pool sequence. Oriented bivalve pelecypod and brachiopod shells and/or molds are distinctive features of this facies. The matrix is dolomitic with a trace of a minor quantity of very fine sand (Plate 17). Facies WPB is inversely graded and occasionally trough cross-bedded or parallel bedded (Plate 18). In well 3-24-68-22W5, the bedding displays irregular shape resembling stromatolitic features. The thickness of this facies range between 0.03m and 0.27m although it is common to find it amalgamated to 0.5m in thickness. The basal contacts of facies WPB are transitional, sharp or erosive and the upper contact is usually sharp.

In the basal part of the carbonate parasequence, the wackestone-packstone may be interbedded with dolomitic mudstone (see Facies DM). The contact between the facies are in most cases sharp. Mudstone beds are thinner and less frequent in the upper part of the carbonate parasequence. In some cases, mudstone beds with lenticular or irregular bedding geometry, and bored contacts with Facies WPB, suggesting that they may be intraclasts contained in Facies WPB that are bigger than the diameter of the core. Similar mudstones are found as intraclasts in the breccia facies (see Facies BR).

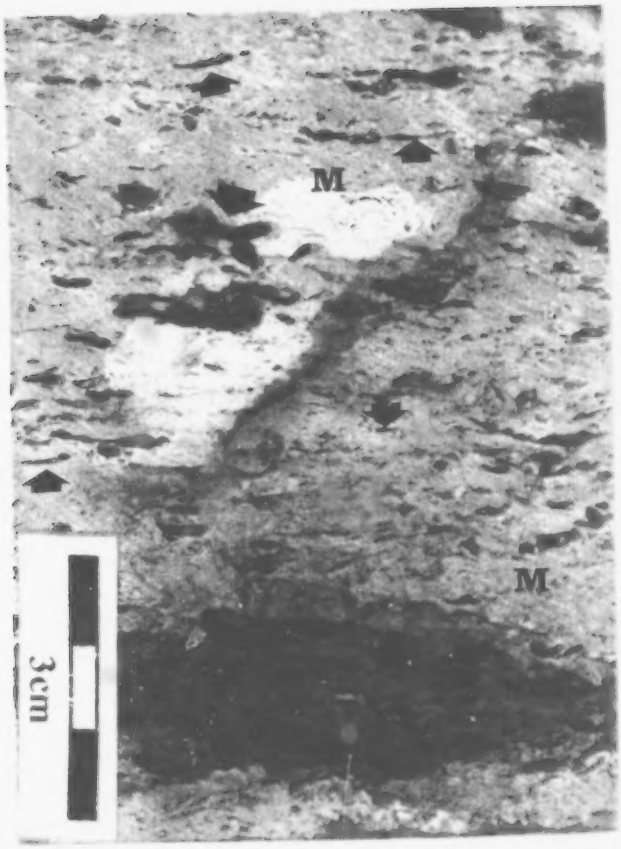


Plate 17: Brachiopod wackestone (Facies WPB). Orientated biomolds (arrows) in a dolomitic matrix (M). Well 3-19-68-21W5. Depth; 5127'3" (1562.79m). Sturgeon Lake B pool.

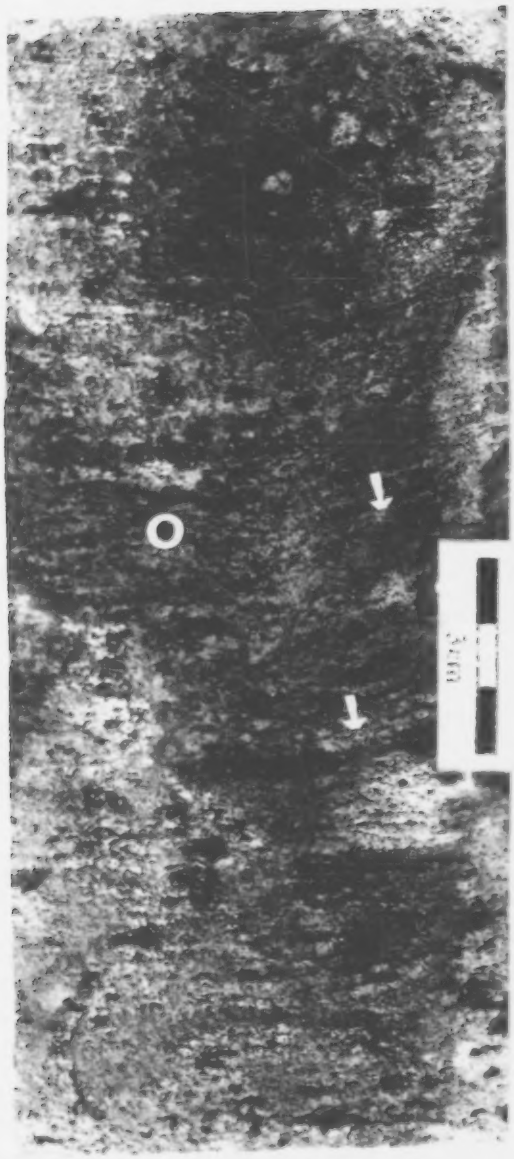


Plate 18: Facies WPB with low angle trough cross bedding (arrow) and oil stain (O). Well 3-24-68-22W5. Depth: 5160'-61' (1572.78m-78.6m). Sturgeon Lake B pool.

Facies WPB sedimentary characteristics, lateral distribution and vertical position in the parasequence suggests that it was deposited in the middle to upper shoreface environment. Inden and Moore (1983) and Tucker (1992) described facies with similar characteristics in the shoreface of shallow marine carbonate progradational parasequences.

Facies WPB is remarkably porous and commonly oil stained, main types of porosity are moldic and vuggy. The facies is also very permeable, with values that range from 212 to 8040md (well 4-10-68-22W5). In terms of reservoir characterization, Facies WPB has the highest permeability values and is relatively thick and homogeneous, constituting the best reservoir quality facies in this study.

6.10.1 Petrologic Description

Following Dunham (1962), Facies WPB can be classified as a bivalve pelecypod and/or brachiopod dolowackestone to dolopackstone. The mineralogy is mainly dolomite, 1 to 20% quartz, and 1 to 4% phosphatic shells and grains. The fabric is 15 to 22% bivalve pelecypods and or brachiopods (mainly molds), fragments of lingulid brachiopods (1 to 5%), micritic grains (0 to 10%), peloids (0 to 10%), and occasional gastropods.

Generally, the bioclasts and molds are moderately to well sorted and in concave and convex concordant orientation. The size of the bioclasts increases upwards. Quartz in this facies ranges from siltstone to very fine sandstone. It is moderately to well sorted and the grains are subangular to subrounded. The porosity of this facies is mainly moldic and vuggy and it may vary from 7 to 27%.

The Dolomite occurs as a replacement and as a void filling (see petrologic description of Facies C). The replacement dolomite is homogeneously distributed over the sample. It is anhedral to subhedral, cloudy, and small to medium in size. The dolomite that occurs as a void filling is larger in size, euhedral, less cloudy and surrounds the molds of the shells. It is not abundant (1 to 5%).

7 MONTNEY FACIES ASSOCIATION

7.1 INTRODUCTION

The variability and succession of sedimentary facies in the Montney Formation at Sturgeon Lake can be best described by two vertical facies associations. The first consists of an upward-coarsening sequence of sediments deposited by storm, current and wave processes and is interpreted as the prograding shoreface of a strand plain, or possibly wave-dominated delta (Figure 29). Facies association 2 is a shallowing upward bioclastic to carbonate sequence deposited also in a prograding shoreface. This facies association is only present in the Sturgeon Lake B pool and is in sharp contact with Facies Association 1 (Figure 30).

The nature of the contact between the two facies associations is not always obvious in the subsurface. In outcrop, however, specifically at the confluence of Whitehorse and Drummond Creek, near Jasper (See Topographic map of Mountain Park Alberta 83C/14. Edition 2), Moslow, (Personal Communication, 1994) there is observed a clear erosive contact between the clastic and carbonate facies associations (Best, 1959; Moslow, Personal Communication, 1994).

The contact between Facies Association 1 and 2 is marked by a major change in lithology. The former is mainly siliciclastic while the later is comprised of wackestone, packstone and mudstone that is highly dolomitized with subordinate quantities of quartz. This contrast infers a different sediment source as well as a different origin of deposition for each facies association. The contact between Facies Association 1 and 2 is interpreted as a sequence boundary.

7.2 BIOSTRATIGRAPHIC ZONATION

Palynological analysis of nine samples were made at the top of each facies association Six of the samples were barren of palynomorphis, however three of them show interesting results. Two of the samples taken in Facies E, at the top of Facies Association 1 in well 11-12-69-22W5 at 4933' (1503.6m) and in well 3-8-69-21W5 at 4920'3" (1499.7m) were identified as Early Triassic, tentatively Smithian to Spathian. This assignment is based on the Peace River Triassic Zonation and the recognition of *Inaperturopollenites nebulosus* (Microplankton), *Spheripollenites balmes* (Microplankton) and *Punctatisporites triassicus* (Spores) (E.H. Davies, Personal Communication).

At the top of Facies Association 2 in well 3-23-68-22W5 at 5133'4" (1564.6m) (Appendix B) the following palynomorphic assemblage was identified:

Microplankton:

Foraminiferal liner
Hystrichospheridium difficile
Micrhystridium petasessitante
Micrhystridium sp Y, Janson '62
Micrhystridium triassicum
Spheripollenites balmei
Spheripollenites elphinstonei

Gymnospermous Pollen:

Cycadopites follicularis
Ephedripites steevesi
Microcachryidites sittleri

Pteridophyte and Bryophyte Spores:

Aculeisporites variabilis
Dictyotriletes mortonis
Punctatisporites triassicus
Sterisporites minimus

Davies (personal communication, 1994) indicates that the aforementioned assemblage is tentatively Late Spathian. These Palynological analysis indicate that between Facies Associations 1 and 2 there are tentatively two Subzones missing within Zone M (Figure 27). This suggests a period of erosion and/or non deposition between the two Facies Associations reinforcing the interpretation of a sequence boundary existing at the contact of Facies Association 1 and 2.

7.3 FACIES ASSOCIATION 1: Siliciclastic Prograding Shoreface.

Facies Association 1 consists of a coarsening upward sequence comprising Facies A to F (Table 2) (Figure 28). Facies A, F, or B occur at the base of Facies Association 1. Facies B is an interlaminated silty shale and very fine sandstone. Sandstone beds are very-fine grained, and have been interpreted as distal tempestites. The silty shale beds represent the post-storm-fair-weather deposition where the dominant process of deposition is suspension. Facies B represents a storm-fair weather sequence (See Johnson and

PEACE RIVER TRIASSIC ZONATION

Barent Sea	Age	Zone	Tentative Subzones
Zone L	Early to Middle Anisian	*Falscisporites zapfei*	
Zone M	Late Spathian	*Microcachryidites sittleri*	*Triadispora plicata* *Paracirculina sp.* *Brachysaccus sp.*
	Early Spathian	*Ooidites barbatum*	*Guttulapollenites sp.* *Crustaesporites globosus*
	?Early Spathian?	Impoverished Zone	*Spheripollenites* exclusively
	Spathian to Smithian	*Pilasporites sp.*	*Verrucosisporites morulae* *Lundbladisp. obsoleta* Peak
Zone N	Smithian	Fungal Hyphae Type 1, (HC&V'89) Peak *	
Zone O	L. Griesbachian to Dienerian	*Lueckisporites sp. cf. L. virrkae*	*Proprisporites pocockii Top* *Aculeisporites variablis* Peak *Monosulcites sp. Balme '79*
Zone P	Early Griesbachian	*Taenieaesporites sp. U* (Jansonius '61) *alias Crucisaccites variosulcites*	Upper Unit A not studied *Vivittina minima* *Gardeniasporites sp. 5*

Figure 27: Peace River Triassic Pollen Zonation (Constructed by E. Davies in: Davies et al, 1994)

Table 2: Summary of Facies Association 1 and 2 for the Montney Formation

Facies Association 1		Facies Association 2	
Facies	**Environment**	**Facies**	**Environment**
E	PROXIMAL LOWER SHOREFACE	**WPB**	MIDDLE TO UPPER SHOREFACE
D	TEMPESTITES OR TUBIDITES (OFFSHORE T/ LOWER SHOREFACE)	**BR**	GRAVITY FLOWS (MIDDLE TO UPPER SHOREFACE)
C	DISTAL LOWER SHOREFACE	**NT**	TEMPESTITES IN LOWER SHOREFACE
B	PROXIMAL OFFSHORE TRANSITION	**DM**	LOWER SHOREFACE
A/F	OFFSHORE TRANSITION		

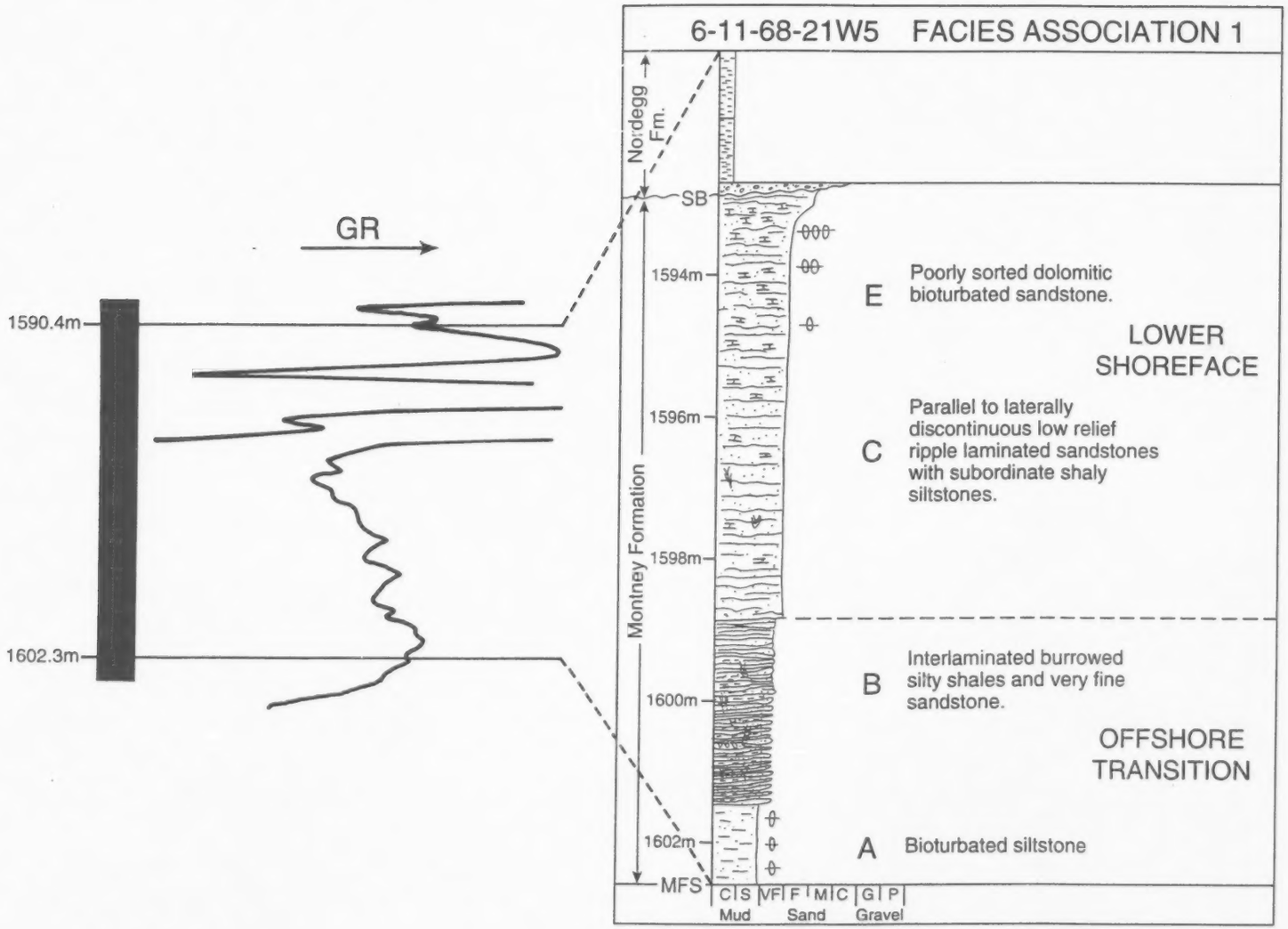


Figure 28: Example of the coarsening -upward Facies Association 1. Legend in Appendix A

Baldwin, 1986; Walker and Plint, 1992; Reineck and Singh, 1971 and Hayes, 1967 among others) in the offshore transition. Although the trace fossil suites which indicate a stressed enviroment have a low diversity, this may suggest a deltaic influence..

Facies B passes transitionally upward to Facies C which is a parallel to discontinuous low-relief ripple laminated sandstone with subordinate shaly siltstone. Sandstone beds are very-fine to fine-grained and are similar but thicker than equivalent sandstone beds in Facies B. The contact between Facies B and Facies C defines the base of the shoreface. Some authors, such as Walker and Plint (1992), placed the base of the shoreface where interbedded sandstones and mudstones grade upwards into relatively clean sandstones. Facies C was deposited in the lower shoreface or in the distal delta front of a wave dominated delta as evidenced by the occurrence of ripple laminations as a main feature of this facies, inferring oscillatory currents produced by wave activity, which normally occur above the fair-weather wave base (Elliot, 1986).

Facies C grades upwards into Facies E (only observable in the Sturgeon Lake A pool) which is a poorly sorted dolomitic sandstone with mottled texture and is the product of intense burrowing and/or dolomitization. Facies E has been interpreted as a deposit in the proximal part of the lower shoreface of a low wave energy coast where biogenic processes predominated.

Facies A, bioturbated siltstone, and Facies F, a dark grey to silty shale generally occur at the base of Facies Association 1. Facies A is interpreted as the result of reworking of sediment by organic activity, and Facies F is interpreted as a product of deposition from suspension. Both cases are related to post-storm deposition in the offshore transition and/or offshore environments.

Facies D is a well sorted, massive appearing to soft-sediment deformed sandstone. Facies D beds occur anywhere within Facies Association 1, but are more conspicuous at the contact between Facies B and C (See well 15-6-69-21W5 and 5-7-69-21W5, Appendix A). Facies D geometry is narrow and elongated parallel to strike (Figure 32).

Facies D has characteristics that infer turbiditic and storm processes within different beds (See chapter 6.4). The concentration of these deposits within the offshore transition (Facies B) and the lower shoreface (Facies C) seems to be a matter of preservation and deposition below fair and/or storm wave base.

In summary, Facies Association 1 is a progradational shoreface sequence deposited by storm and wave processes along a strand plain maybe with a deltaic influence. Wave energy is the major factor controlling sedimentation in wave-dominated shorelines (Johnson, 1919; Johnsen, 1961; Zenkovitch, 1967; King, 1972 from Reineck and Singh, 1975). In broad terms there are two types of wave-dominated coasts: High energy coasts

where average wave heights are very high; and low energy coasts where average wave heights are relatively low (Reineck and Singh, 1975; Davies and Hayes (1984). In comparison with different examples of beach-shelf profiles from modern environments in both high and low energy coasts, Facies Association 1 is similar to the offshore transition and lower shoreface of Galveston Island in the Gulf of Mexico which is a coarsening upward shoreface sequence deposited along a modern barrier island (Reading, 1986). Galveston Island is characterized by storm deposited beds of sand in the offshore transition and shoreface environments. The bioturbation of these deposits reflects low wave energy conditions (Reading, 1986) (Figure 29). Facies Association 1 is therefore interpreted as having been deposited in a prograding shoreface of a low energy strand plain in which sedimentation is dominated by storms and wave processes.

7.4 FACIES ASSOCIATION 2

Facies Association 2 consists of dolomudstones, wackestones and packstones (Facies DM, NT, BR, and WPB) (Table 2) and disconformably overlies Facies Association 1. Facies Association 2 is a shallowing and coarsening upward sequence deposited in the shoreface zone of a shelf-ramp setting (Figure 30 and 31).

At the base of Facies Association 2, Facies DM and Facies WPB are commonly interbedded. Facies DM (dolomudstone) and Facies WPB (brachiopod wackestone-packstone), have both been interpreted as being deposited in the lower shoreface. Facies DM grades upwards to a thicker-bedded, massive brachiopod wackestone-packstone of (Facies WPB). The Brachiopod Wackestone-Packstone is an accumulation of orientated pelecypod and brachiopod valves in a dolomitic matrix. Beds are inversely graded and have been interpreted as a middle shoreface deposit. However,overlying beds within this facies are coarser packstones and grainstones which are parallel- or trough cross-bedded. These characteristics infer wave processes of deposition likely within the upper shoreface zone. Similar shallow-marine carbonate progradational sequences have been described by Inden and Moore (1993) and Tucker (1992) (Figure 31). In summary, Facies Association 2 represent a carbonate prograding shoreface sequence deposited in a shelf ramp setting adjacent to a strand plain.

Facies NT commonly occurs in Facies Association 2. It is normally graded, bioclastic, coarse- to fine-grained sandstone or brachiopod wackestone and has been interpreted as a product of storm deposition. These tempestite beds infer moderate activity in the shelf ramp setting during deposition of Facies Association 2.

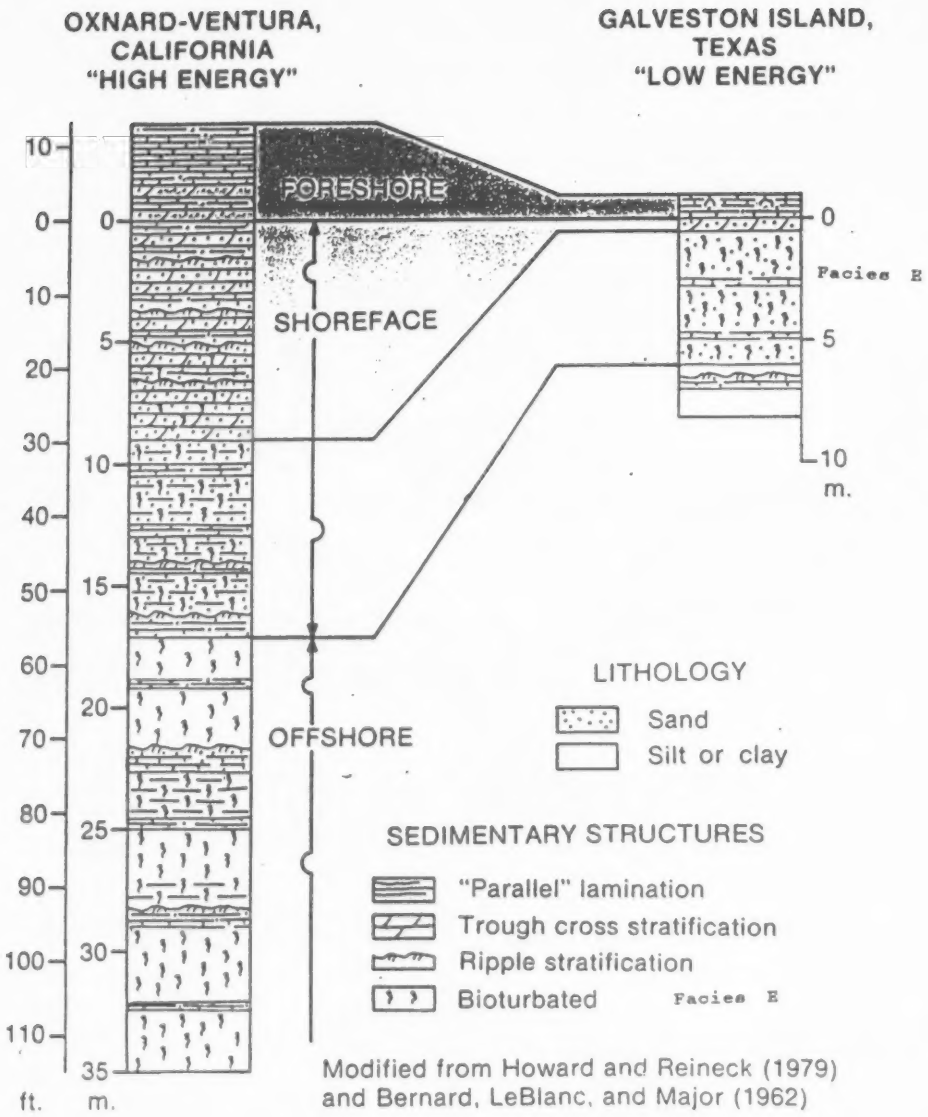


Figure 29: Sand body and vertical coarsening-upwards sequence produced by seaward migration of Galveston Island, Texas (After Bernard, LeBalnc and Major, 1962 and McCubbin, 1982) (From Reading, 1986).

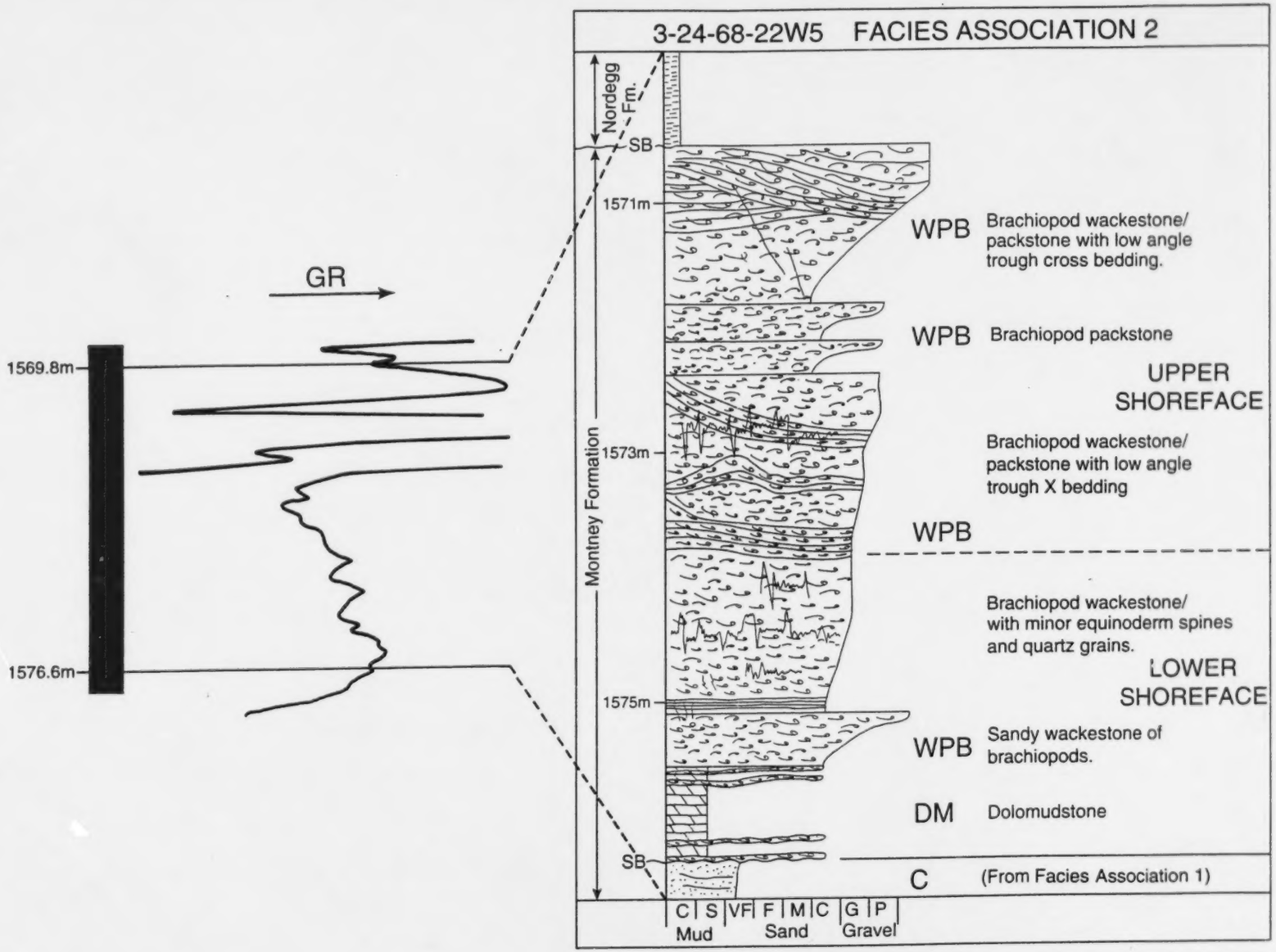
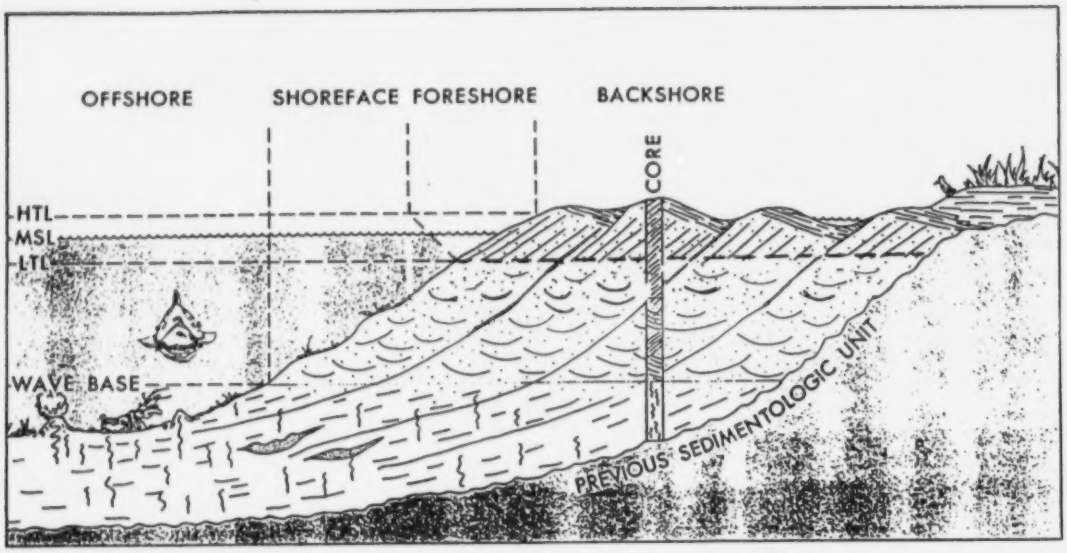


Figure 30: Example of the coarsening -upward Facies Association 2. Legend in Appendex A



ZONES	TYPICAL E-LOG (Before Burial) SP Res.	GRAIN SIZE Coarse Fine	SORTING Poor Well	LITHOLOGY	CORE	SEDIMENTARY STRUCTURES	PROCESSES
FORESHORE				Grainstone		Parallel Laminations Small Scale Avalanche Cross Bedding Fine Graded Laminations Vertical Burrows	Wave Swash
SHOREFACE				Grainstone to Packstone		Small to Medium Tabular Festoon Crossbeds	Directed Tidal and Along Shore Currents
OFFSHORE				Packstone to Wackestone		Horizontal Branching Burrows	Biologic

Figure 31: Generalized progradational shoreface model for carbonate facies. Conceptualized after Bernard and Majors (1962). (From Inden and Moore, 1983).

Facies BR only occurs in wells 3-23-68-22W5 and 9-4-69-22W5 and has been defined as a sedimentary breccia. Rounded clasts of mudstone occur in a dolomitic matrix within normally graded beds. Facies BR is interpreted to originate from erosion of an exposed carbonate terrain and subsequent transport of these clasts to the shoreface, likely by geostrophic or gravity flows.

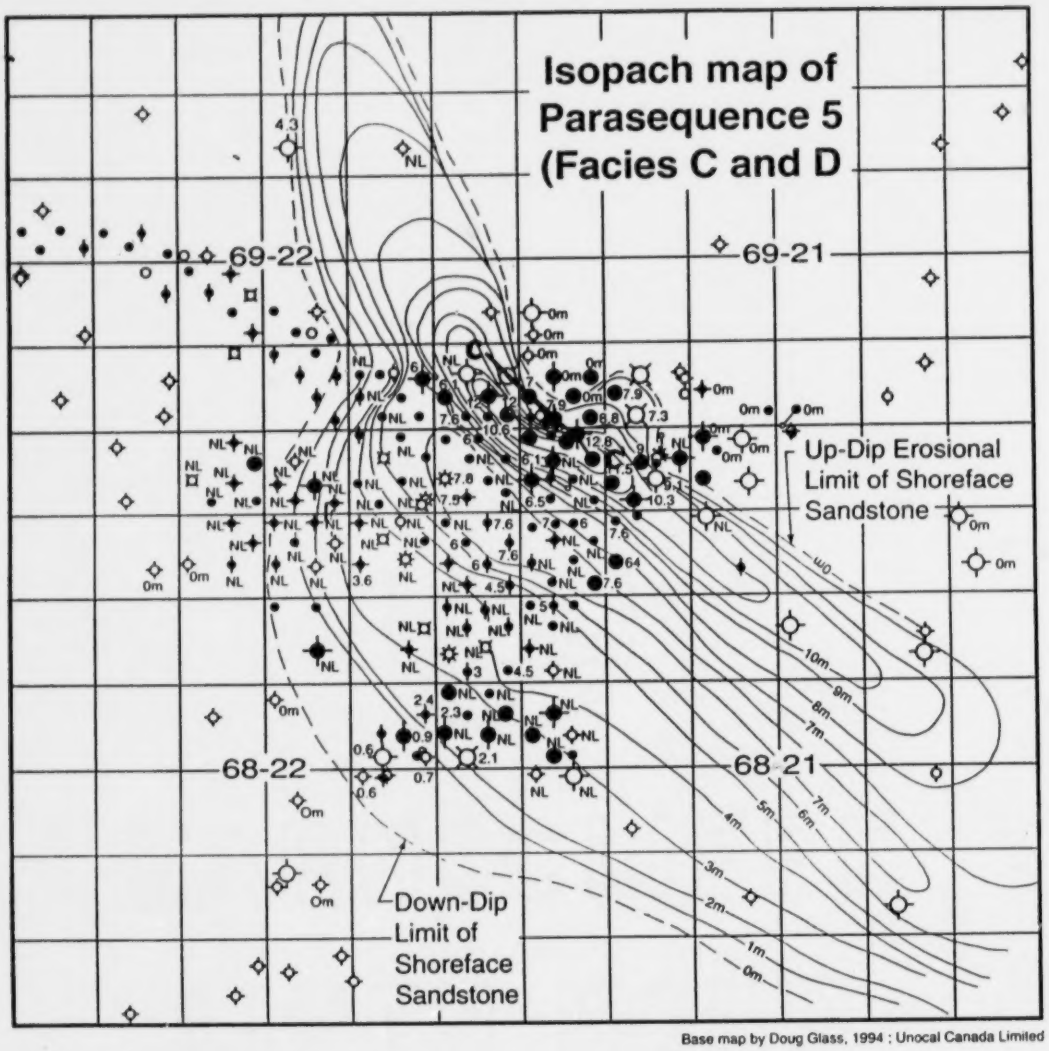
The upper portion of both Facies Association 1 and 2, are differentially eroded and thus incomplete sequences in the Sturgeon Lake area. Facies Association 1 is truncated by Facies Association 2 in the Sturgeon Lake B pool and by the pre-Jurassic unconformity in Sturgeon Lake A pool. Facies Association 2 is truncated by the pre-Jurassic unconformity, which has eroded a considerable portion of this Facies Association.

7.5 LATERAL FACIES RELATIONSHIPS AND FACIES ASSOCIATION GEOMETRY

Facies Association 1 does not vary markedly in the Sturgeon Lake Area. It constitutes an elongated strike-linear body where the thickness increases abruptly near the paleo-shoreline and decreases gradually basinward (Figure 32). Facies correlation of Parasequence 5 (Figure 33) shows the distribution and geometry of sedimentary facies within Facies Association 1 along depositional strike. Facies Association 1 characterizes Parasequences 4, 5 and 6 (See Chapter 8) and possibly Parasequences 1, 2 and 3. There is no core control for the latter parasequences. The stacking pattern of Parasequences 1 through 6 displays a sigmoidal to clinoform geometry along depositional dip (See Cross-section A-A') and an aggradational stacking geometry along depositional strike.

The lateral variability of sedimentary facies in Facies Association 2 of Parasequence 9 is as shown in Figure 34. Along depositional dip (WPB) shoreface facies grades basinward into storm deposits of Facies NT (see well 7-23-68-22W5 Figure 34). Landward, the WPB Facies thickens and grades into an upper shoreface Facies.

An isopach map of Facies Association 2 was made using core and gamma-ray logs (Figure 35). Facies Association 2 occurs as a series of linear ridges elongated parallel or oblique to depositional strike. These ridges are only partially connected and are laterally discontinuous. The thicker trends coincide with more complete Facies Association 2 sequences that vertically display lower shoreface and upper shoreface facies. Unfortunately, Facies Association 2 is truncated by the Nordegg Formation making it difficult to conclude whether or not the observed geometries are depositional, erosional or both in nature. The lateral discontinuity and variablitiy in geometry of Facies Association 2



Legend

- Suspended oil well
- Abandoned oil well
- Producing oil well
- Suspended well
- Dry hole
- Location and drilling
- Highlighted well with Triassic core
- 7.6 Thickness in meters
- 3m Isopach contour line
- NL No Gamma Ray well log for interval

Scale: 1:100,000

Figure 32: Isopach map of Parasequence 5

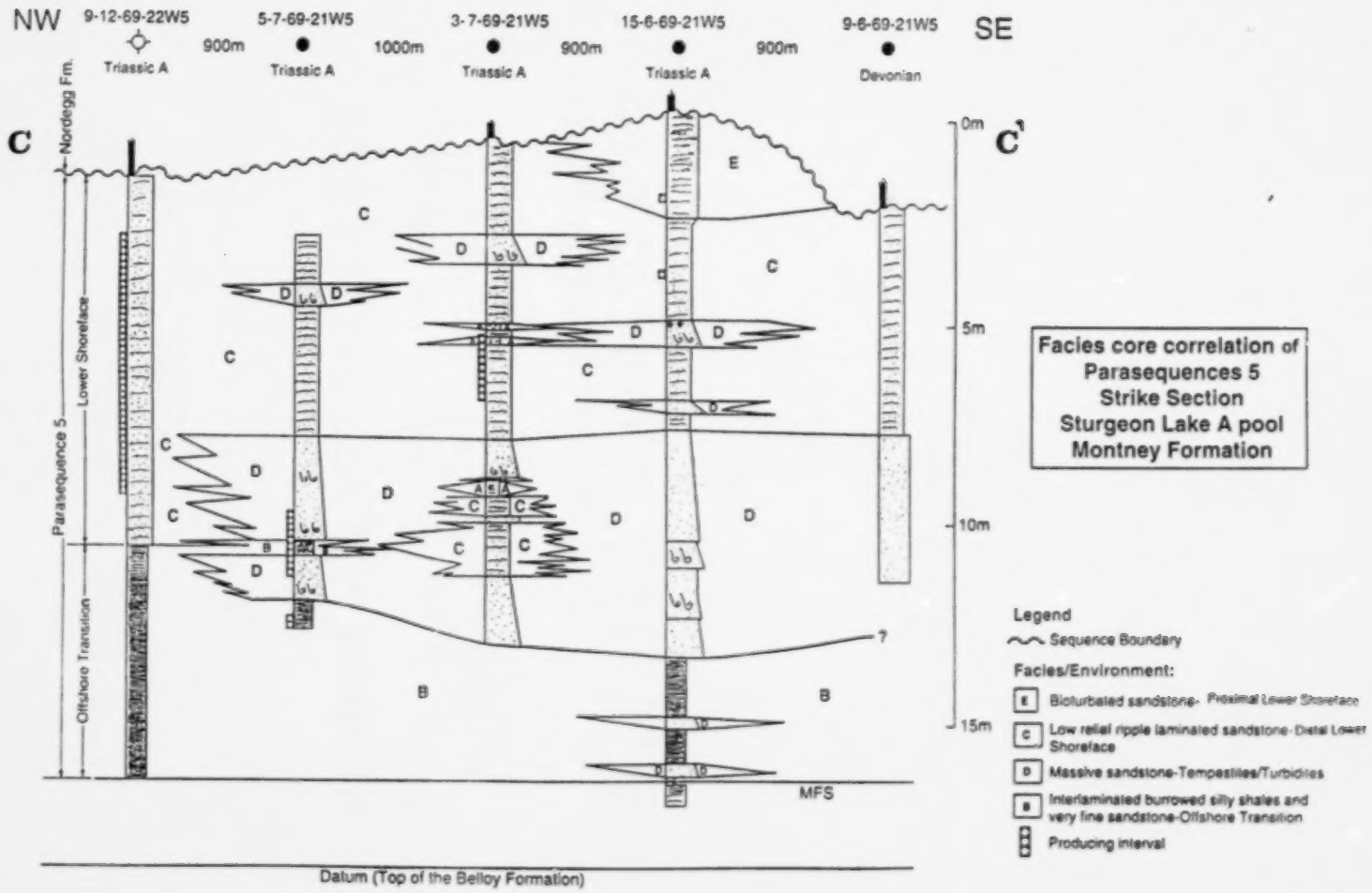


Figure 33: Facies correlation of Parasequence 5 (CC'). Location of cross-section shown in Figure 32.

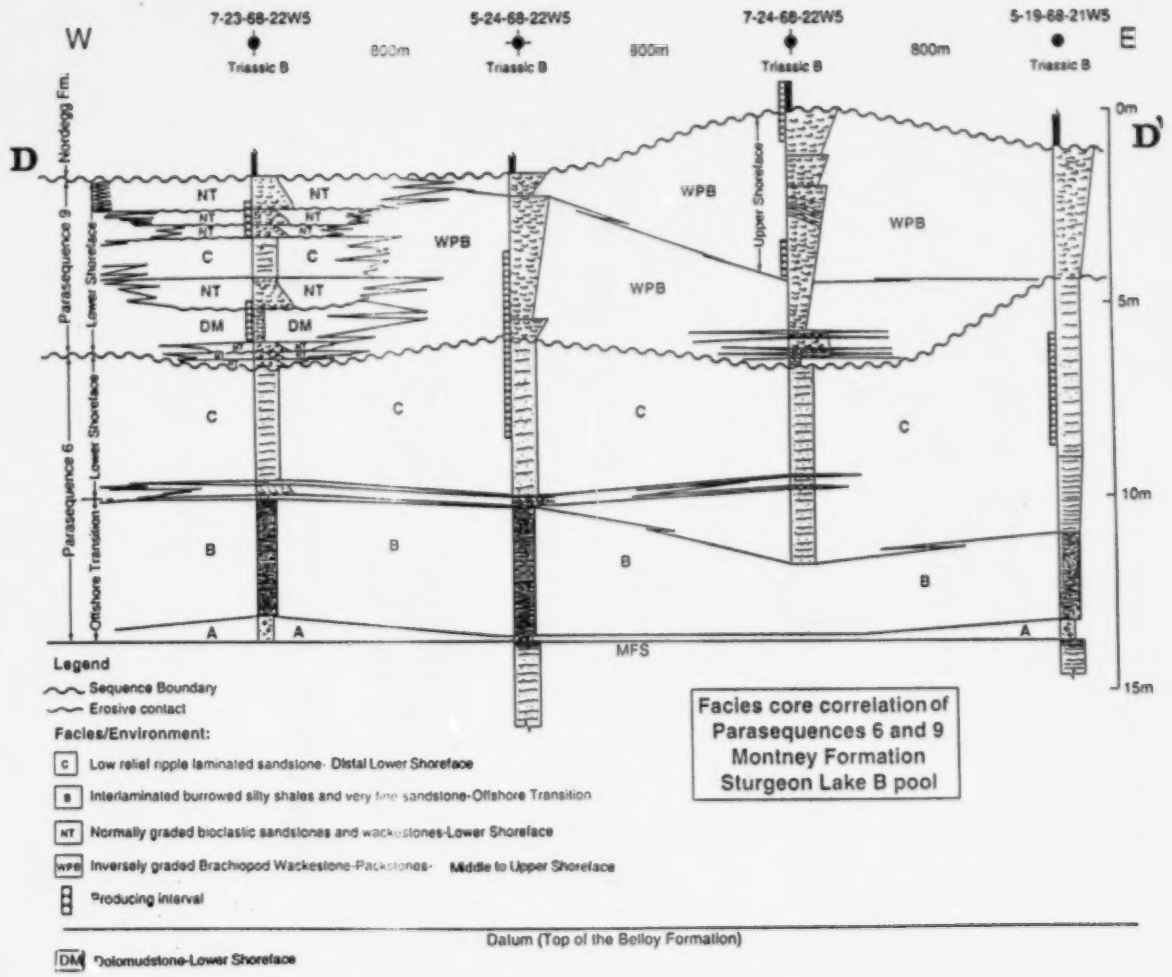
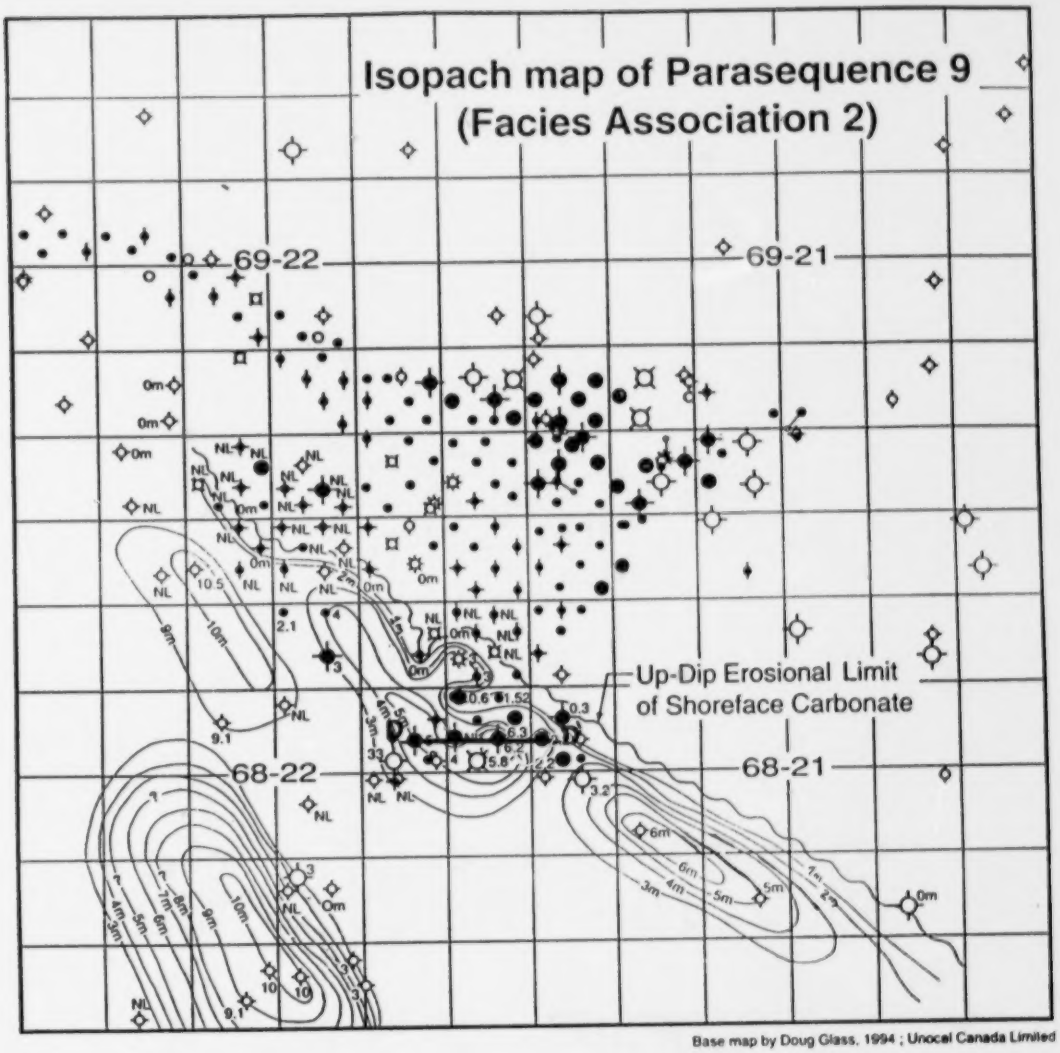


Figure 34: Facies Correlation of Parasequences 6 and 9. (DD'). Location of cross-section shown in Figure 35.



Legend

- Suspended oil well
- Abandoned oil well
- Producing oil well
- Suspended well
- Dry hole
- Location and drilling
- Highlighted well with Triassic core

- 7.6 Thickness in meters
- 3m Isopach contour line
- NL No Gamma Ray well log for interval

Scale: 1:100,000

Figure 35: Isopach map of Parasequence 9

is at least in part due to post depositional differential erosion and truncation from the overlying pre-Cretaceous (Nordegg) unconformity. However, an alternative explanation is that the observed geometry is depositional in nature. As such, the linear trends observed in Figure 35 are shoreface-attached ridges, similar to those observed along the eastern coast of the Mid-Atlantic United States as described by McBride and Moslow (1990).

8 SEQUENCE STRATIGRAPHY

The sequence stratigraphic terminology and concepts used in this study are based on those presented by Van Wagoner *et al.*, (1990) and Plint (1994). The Montney Formation in the study area consists of two sequences. These sequences are bounded by two major erosional surfaces, the sub-Triassic and the sub-Jurassic unconformities (Gibson and Barclay , 1989). The sub-Jurassic unconformity is clearly visible in cores and gamma rays and SP well logs. In core, the unconformity is marked by a sharp and erosional contact between sandstones or carbonates of the Montney Formation and black shales of the Nordegg Formation (See Appendix A). Gamma ray, Resistivity, and SP well logs show an abrupt shift to the right due to a more radioactive or electrical response (Figure 36).

The sub-Triassic unconformity is the contact between the Belloy Formation, which is Permian in age (Gibson and Barclay, 1989) and the Montney Formation. In the study area, this contact is not cored but is easily recognized in Gamma Ray and SP well logs. The contact is marked by a change in response from a funnel-shape coarsening upward Gamma Ray and SP logs profile to a blocky Gamma Ray or SP log profile and abrupt shift to the right (Figure 36). The contact displays a radioactive peak on the Gamma-ray log.

Stratigraphic cross-sections AA' and BB' (Figures 37 and 38) best display the geometry and stacking of parasequences along depositional dip and strike respectively. The datum used for both sections is the top of the Belloy Formation. This datum works very well in the study area because almost all wells in the area penetrate the Belloy Formation. In addition, the top of the Belloy formation is easy to recognize in Gamma Ray, SP and Resistivity logs. The Belloy Formation is regionally extensive with only minor differences in log response. Finally this datum provides for observation of Montney parasequence configuration .

Two sequences are observed in the Montney Formation in the Sturgeon Lake Area. The first or older sequence (S1) has been subdivided into 8 parasequences (1 to 8, Figure 37) occurring within Transgressive and Highstand Systems Tracts. Parasequences 1, 2 and 3 comprise the Transgressive Systems Tract. The Transgressive Surface of Erosion (TSE) is defined as the first significant flooding event (Van Wagoner *et al.*, 1988). This surface is located at the top of the Belloy Formation where the Gamma Ray and SP logs display a shift to a more radioactive or electrical response (Figure 36 and 37). There is a tendency for each parasequence to thin and pinch-out basinward and onlap landward, thus forming a retrogradational parasequence set. As observed in the area of greater well

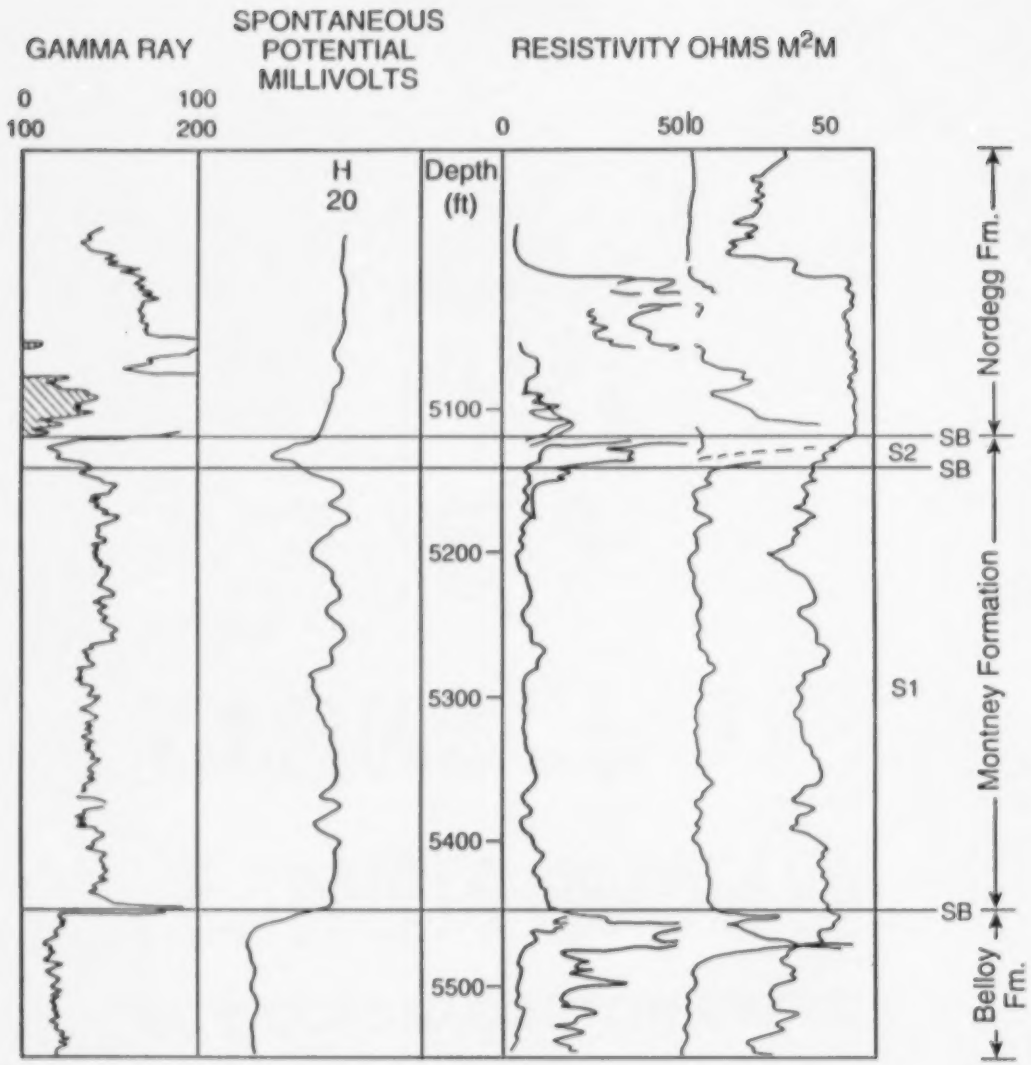


Figure 36: Characteristic Gamma Ray, SP and Resistivity log responses in well 5-32-68-21W5for the Montney Formation in Sturgeon Lake A and B pool. S1= Sequence 1, S2=Sequence 2, SB=Sequence Boundary.

diversity, Parasequence 3 tends to be thinner than Parasequence 2. This upward thinning of parasequences is also typical of a retrogradational parasequence set (Van Wagoner *et al.*, 1988) in the Transgressive System Tract. The maximum flooding surface is placed at the base of Parasequence 4 and is marked by the most radioactive signature Gamma Rays, SP and Electrical log response within the Montney. The maximum flooding surface marks the upper boundary of the Transgressive Systems Tract.

Parasequences 4 through 8 comprise the Highstand Systems Tract. These parasequences have an aggradational (Parasequence 4 and 5) to increasingly progradational pattern (PS 5 to 8). Parasequence 4 downlaps seaward and is planar landward, characteristic of the early phases of deposition of a Highstand Systems Tract. Parasequence 5 probably has a similar geometry to Parasequence 4, but is truncated landward by the pre-Cretaceous Nordegg unconformity. Parasequences 6, 7 and 8 have more conspicuous clinoform shape with apparent toplap geometry in the upper part of each parasequence and downlap geometry seaward. The latter geometry is more typical of the later stages of the Highstand Systems Tract (Plint, 1994).

Parasequence 6, 7 and 8 are truncated by a 3rd order sea level fluctuation that generated a sequence boundary and (Figure 37) defines the base of sequence 2. Sequence 2 is comprised of Parasequence 9 which is carbonate (Facies Association 2, See Chapter 7) and is truncated by the pre-Cretaceous unconformity. Parasequence 9 has been interpreted as the beginning of a Transgressive System Tract for the following reasons: 1) by analogy to Davies, *et al.*, (1993) regional correlations of the Montney Formation; 2) because in Transgressive Systems Tract, rapid relative sea level rise allows the carbonate factory to operate at optimum capacity (James and Kendall, 1992); the presence of Montney carbonate facies is unique to parasequence 9 and 3) Parasequence 9 immediately overlies a coplanar sequence Boundary/Transgressive shoreline erosion.

Finally if the interpretation of a SB at the base of Parasequence 9 is correct, then this SB/TSE divides the Montney Formation into two distinctive stratal sequences that are likely recognizable throughout the basin. A similar stratigraphic relationship is observed by Davies *et al.*, (1994).

9 RESERVOIR CHARACTERIZATION FOR THE STURGEON LAKE AREA

There are two main reservoir facies within the Montney Formation in the Sturgeon Lake Area; one carbonate and one clastic. Both have markedly different lithologies, porosity types, permeabilities and geometry. Therefore both reservoir facies have a different mechanical behavior as flow units.

The clastic reservoir facies consist of Facies C and D (Lower Shoreface proximal Offshore Transition). Facies C and Facies D are interconnected and therefore should be considered from a reservoir point of view as one flow unit. Facies C and D are very-fine to fine-grained sandstone with interparticle primary porosity that may vary between 5 and 35%. Facies C is an interlamination of quartzarenites, quartzwackes and hybrid sandstones and porosity is only present in the quartzarenites. However, the quartzarenites laminae become more abundant toward the top of the facies and there is a tendency of porosity enhancement toward the top of the facies. Facies D, on the other hand, is better sorted and more homogeneous than Facies C.

Diagenetic factors such as compaction and cementation do not seem to be a major control on primary porosity of these facies. Permeability for these units may vary from 10 md to 132 md with a mean value of 21 md. However, Facies D has zones with very high permeabilities (*i.e.* 37080 md) related to open fractures (Plate 11) (See well 15-6-69-21W5, 14-6-69-21W5). The geometry and thickness of this flow unit is shown in the isopach map of the reservoir facies (C and D) in Parasequence 5 (Figure 32). Maximum thickness is approximately 12m. The thicker interval is located near the Paleo-shoreline parallel to depositional strike and gradually thins and pinches out basinward to the southwest toward the basin (Figure 32). Sequence 1 is comprised of retrogradational (Parasequence 1 to 3) and progradational (Parasequences 4 to 8) parasequence sets (Plate 37). The reservoir facies interval to these parasequences maintain the same sedimentary characteristics through time. This conclusion is based on observation of cores within Parasequences 4, 5 and 6. The geometry of these Parasequences indicates that there may be an increase in the thickness of interval flow units along strike. In the southwest part of the Sturgeon Lake area, clastic shoreface facies flow-units tend to thin and pinch-out within the lower parasequence set and prograde for the upper parasequence set.

Facies WPB and NT are brachiopod wackestone and packstone with excellent moldic and vuggy porosity as a product of leaching of the bioclasts. The pores are large, reaching 2cm or more, and the pore size is related to the actual size of the valve.

Compaction or cementation after dissolution were not major factors that affected the porosity of these facies. It is common to find Facies WPB and NT oil stained, such that in many cases it is difficult to recognize sedimentary structures. Visual porosity estimations were made in Facies WPB they vary from 7 to 27%. Permeability is also very high with values that range from 212md to 8040md (well 4-10-68-22W5) (Appendix A). The higher permeabilities found in this facies seem not to be related with fractures. However, in some cores, fractures are observed in this facies (Plate 15). The carbonate reservoir facies constitute one single flow-unit that extends through the Sturgeon Lake B pool area with variable thickness (Figure 35). Thickness variability may be due to differential erosion and/or depositional origin as shelf/shoreface sand ridges. This flow unit may be interconnected in some areas with clastic flow units (Parasequence 6 and 9 in T68, R 14 and 24, Figure 37).

10 CONCLUSIONS

The Montney Formation in the Sturgeon Lake A and B pools can be divided into two depositional sequences: the Lower Sequence and the Upper Sequence. The lower Sequence (Sequence 1) is bounded by the major sub-Triassic unconformity at the base, and by a minor unconformity with the overlying sequence 2. The Upper Sequence (Sequence 2) is a carbonate unit bounded on the top by the pre-Jurassic unconformity.

Palynological analysis indicates that between Sequence 1 and Sequence 2, there are two palynologic sub-zones missing (Sub-zones of *Spheripollenites* exclusively and a sub-zone of *Guttulapollenites sp- Crustaesporites globosus*) suggesting a period of erosion or non-deposition between Sequence 1 and Sequence 2. Sequence 1 has been dated Spathian to Smithian, while Sequence 2 is tentatively dated to the Late Spathian (Davies, Personal Communication 1994).

The base of Parasequence 9 bounding Sequence 1 and 2 and is interpreted as a SB of regional extent. Sequence 1 is composed of eight coarsening upward parasequences which are retrogradational, aggradational and progradational, representing Transgressive and High -stand Systems Tracts. Sequence 2 is comprised of Parasequence 9. By its lithological nature (carbonates), by analogy with other studies, it is interpreted as a Transgressive System Tract.

The Parasequences in Sequence 1 consist of one facies association (Facies Association 1). This represents a progradational coarsening upward, storm-wave dominated strand-plain, maybe with deltaic influence deposited in the offshore transition and lower shoreface or the distal delta front. Along this strand plain, the storm processes seems to be the main factor in controlling deposition. It is interpreted that these sediment accumulations occurred along low-energy coast.

The carbonate unit (Sequence 2) is a coarsening upward progradational sequence deposited in the shoreface of a strand-plain on a shelf ramp setting.

The Montney Formation has four facies with reservoir potential, which can be subdivided into two major groups based on their possible behavior as flow units: Carbonates and Clastics.

The reservoirs (flow units) in the Sturgeon Lake A and B pools seem to be mainly the product of stratigraphic controls (Facies and depositional geometry) for the siliciclastics (Sequence 1), and stratigraphic and diagenetic controls for the carbonates (Sequence 2) with possible enhancement by some other factors like fractured zones.

The porosities for the clastics (Facies C and D) and for the carbonates (Facies WPB and NT) are very similar, reaching occasionally 35%. The permeabilities, however, show substantial differences. They range from 21 md average in the clastic facies to 400 md average in the carbonate facies. The better permeabilities in the carbonate units make the carbonates the reservoirs with the best potential. Unfortunately these carbonate flow units are restricted to the Sturgeon Lake B pool.

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APPENDIX A

Appendix A contains Montney cores described from the study area.

Legend:

Lithology

Sandstone

Sandstone with shale laminaes

Conglomeratic sandstone

Shale

Dolomite

Bioclast material

Lithological Contacts

 Sharp contact

Erosive contact

Angular contact

Sedimentary, Biogenic, Diagenetic Structures:

Dewatering structures

Bioturbation

Rosselias

Teichichnus

Skolitos

Shell

Ripples

Graded bed

Inversely graded bed

Finning upward

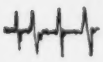
Coarsening upward

Planar lamination

Trough-cross lamination

Trough-cross bedding

Load cast


Stylolites

Dolomite cement

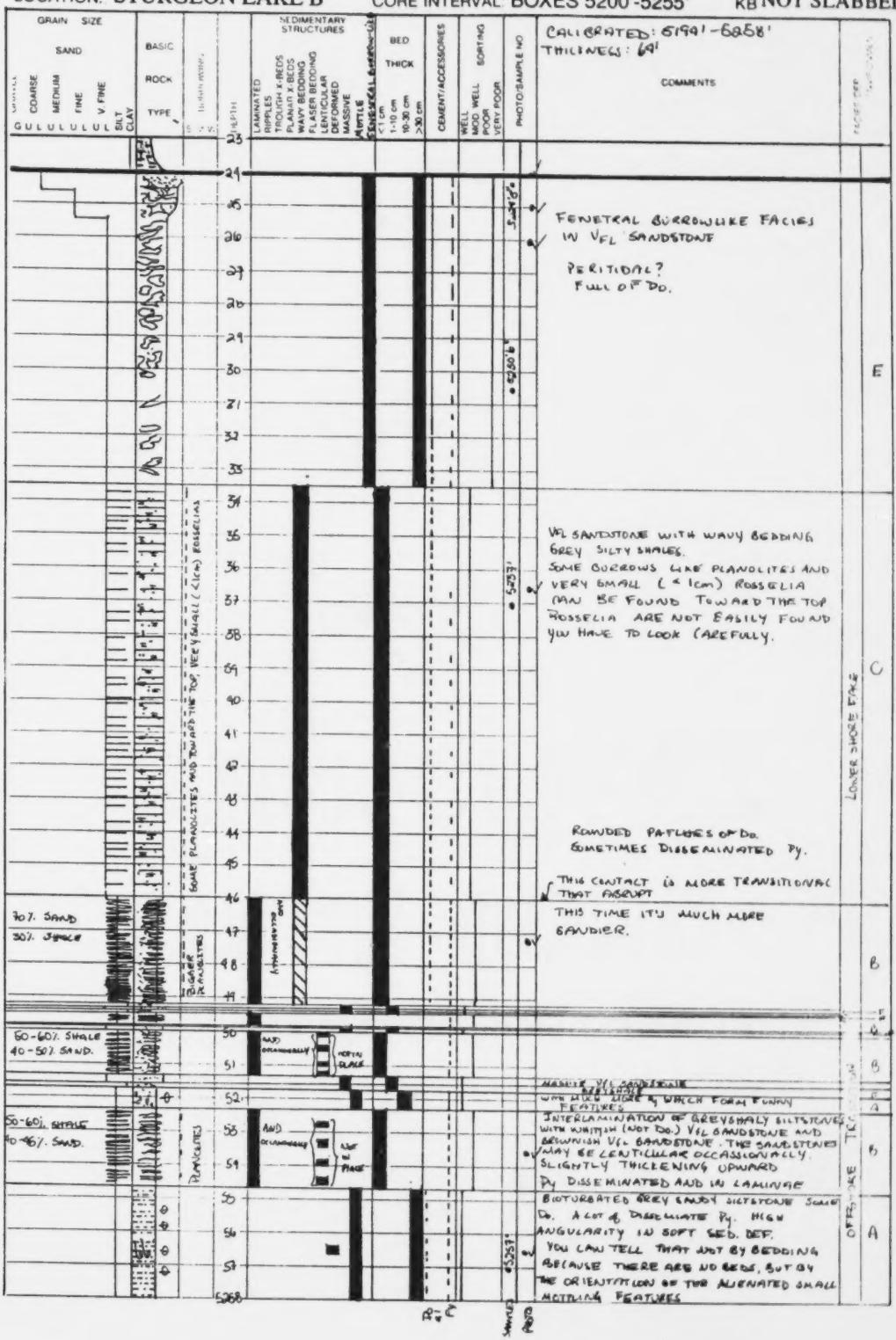
Mottled texture

Sample

Sample with palynological data

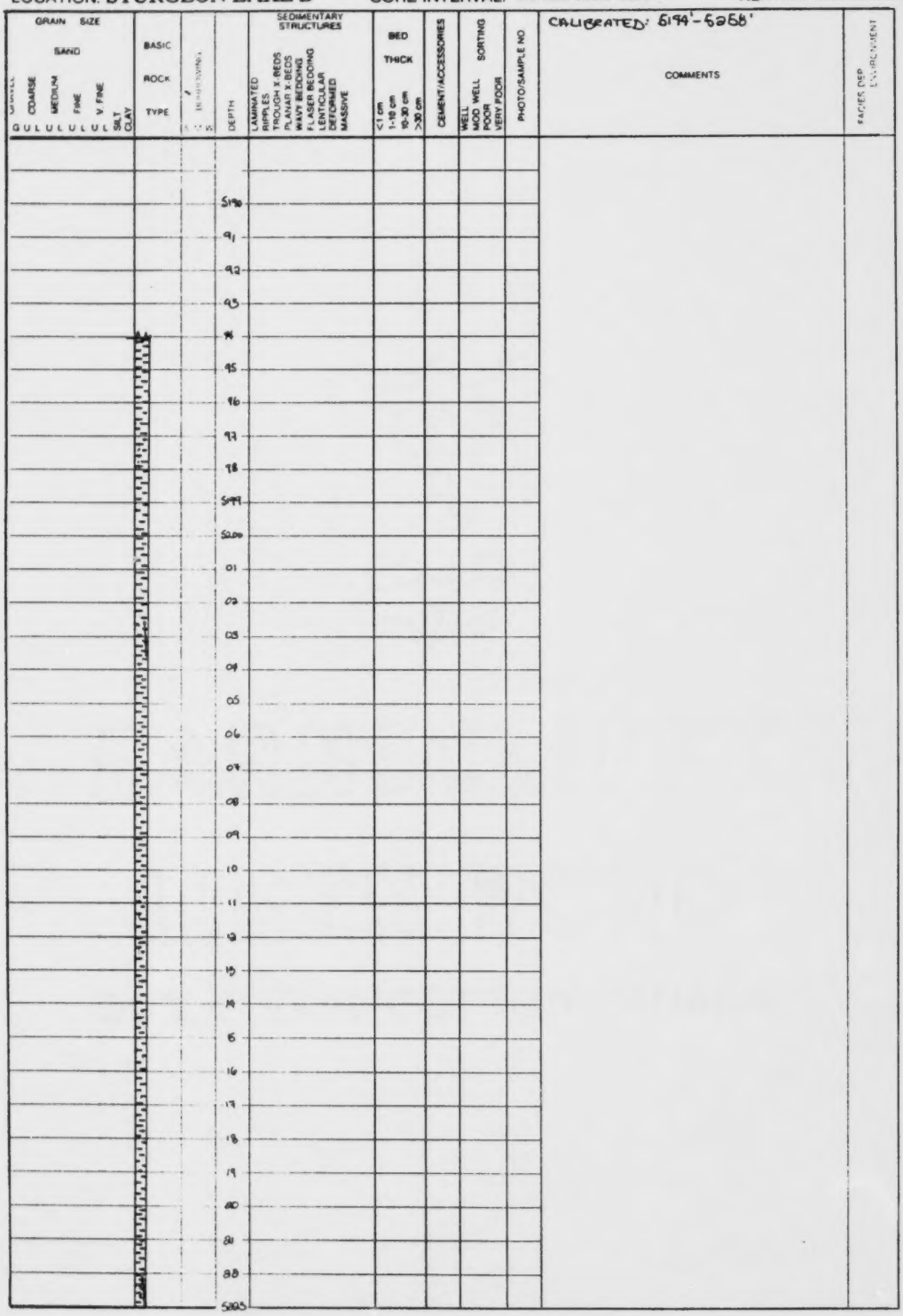
WELL NAME: 6-11-68-21W5 (1 OF 2) FORMATION: MONTNEY DATE: SEPT. 20, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5200'-5255' KB NOT SLABBED


GRAIN SIZE
SAND
GRANULE COARSE MEDIUM FINE V FINE SILT CLAY
BASIC ROCK TYPE
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED RIPPLES TROUGH X-BEDS PLANAR X-BEDS WAVY BEDDING FLASER BEDDING LENTICULAR DEFORMED MASSIVE MOTTLE
BED THICK
CEMENT/ACCESSORIES
WELL MOD WELL POOR VERY POOR SORTING
PHOTO/SAMPLE NO
COMMENTS
CALIBRATED: 5191'-6858'
THICKNESS: 69'
FENESTRAL BURROWLIKE FACIES IN VFL SANDSTONE
PERITIDAL?
FULL OF Do.
VFL SANDSTONE WITH WAVY BEDDING GREY SILTY SHALES.
SOME BURROWS LIKE PLANOLITES AND VERY SMALL (< 1cm) ROSSELIA (MAY BE FOUND TOWARD THE TOP ROSSELIA ARE NOT EASILY FOUND YOU HAVE TO LOOK CAREFULLY.
ROUNDED PATCHES OF Do. SOMETIMES DISSEMINATED Py.
THIS CONTACT IS MORE TRANSITIONAL THAT ABRUPT
THIS TIME IT'S MUCH MORE SANDIER.
70% SAND
30% SHALE
60-70% SHALE
40-50% SAND.
50-60% SILTST
40-50% SAND.
PLANOLITES
SOME PLANOLITES AND TOWARD THE TOP, VERY SMALL (<1cm) ROSSELIAS
LOWER SHOREFACE
OFFSHORE TRANSITION
C
E
B
A

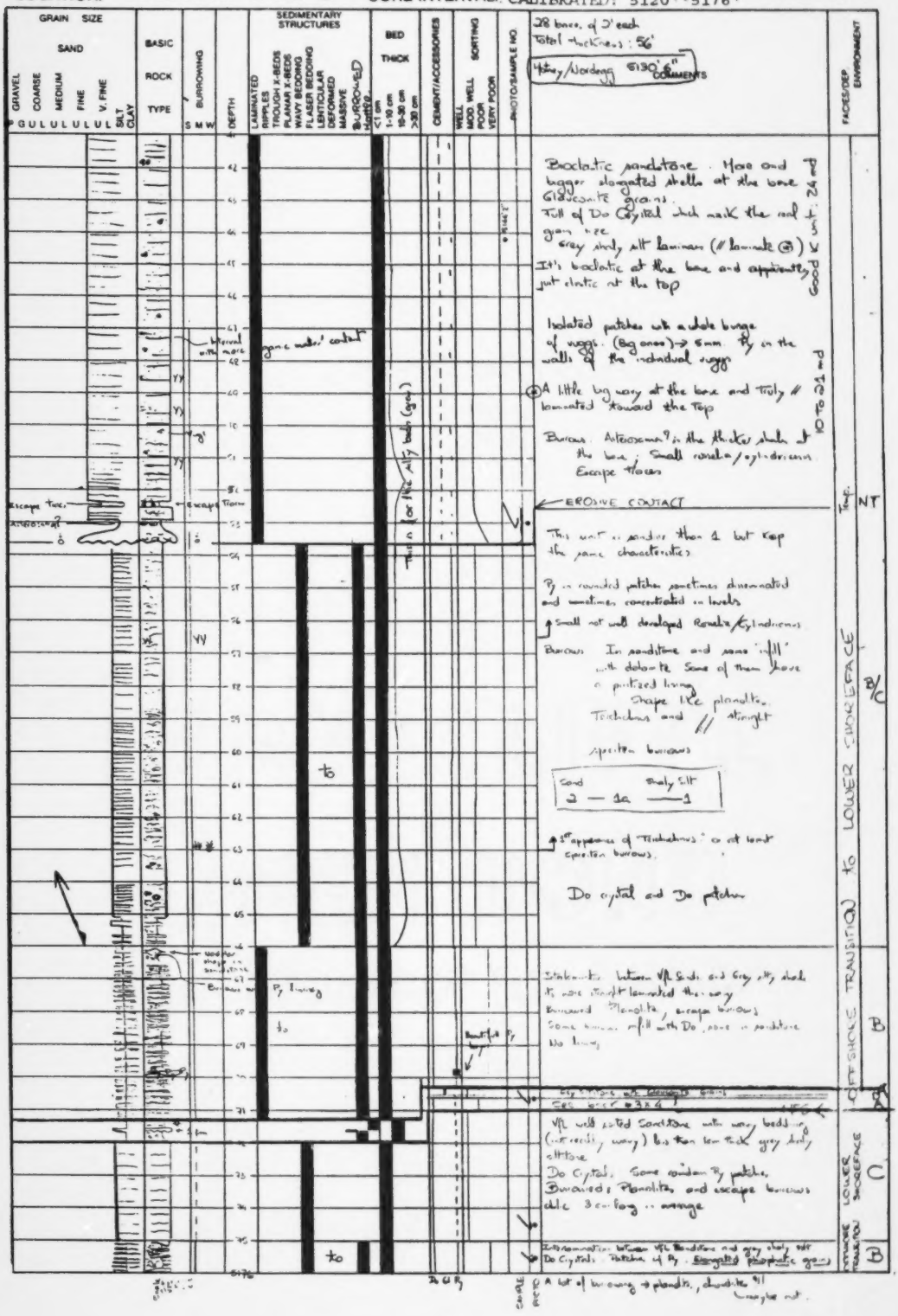
WELL NAME: 6-11-68-21W5 (2 OF 2) FORMATION: MONTNEY DATE SEPT. 20, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5200'-5255' KB: NOT SLABBED



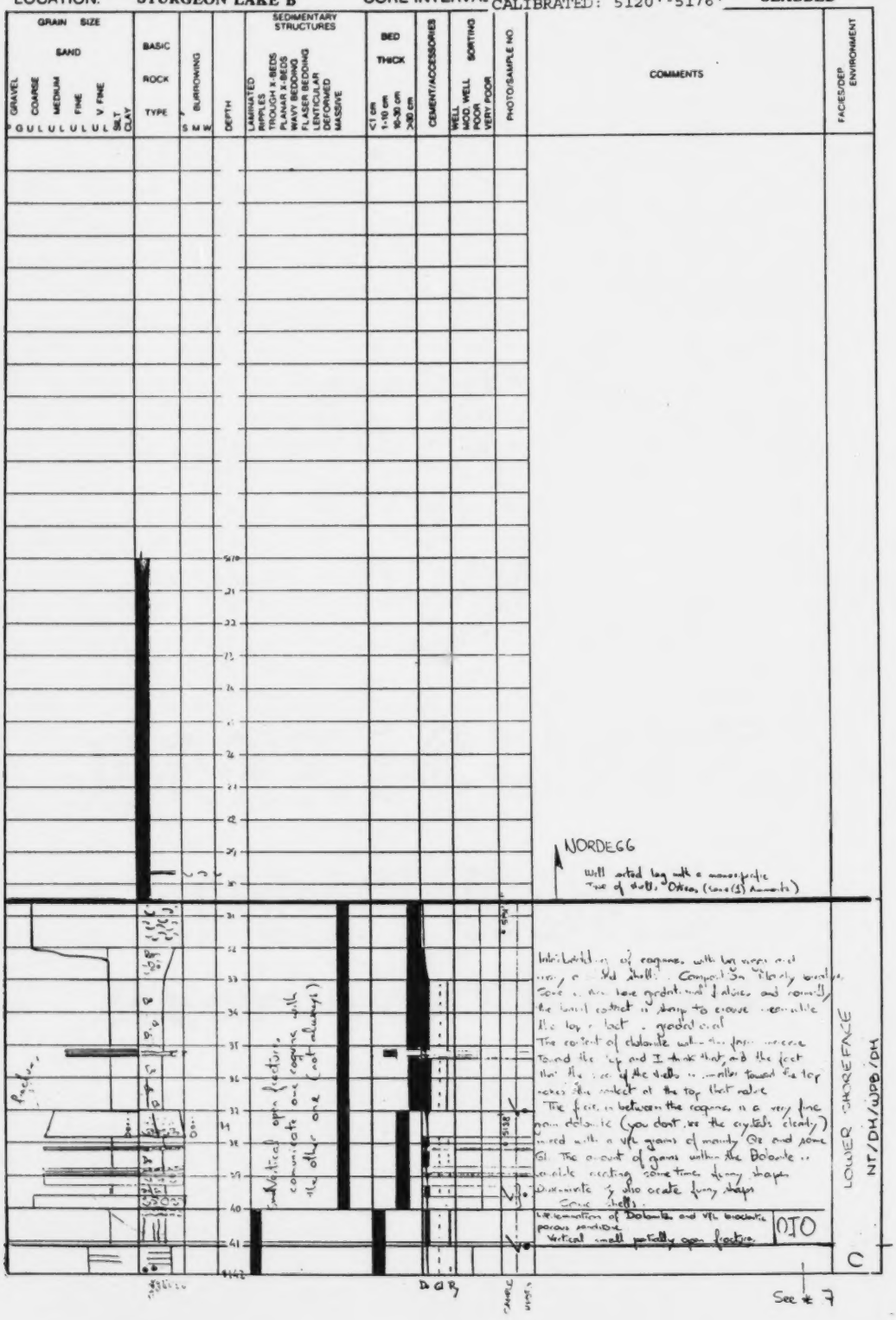
WELL NAME: 15-18-68-21W5(1 OF 2) FORMATION: MONTNEY DATE: SEPT 21, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5119'-5174' CALIBRATED: 5120'-5176' SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
S M W
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR BEDDING
DEFORMED
MASSIVE
BURROWED
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD. WELL
POOR
VERY POOR
PHOTO/SAMPLE NO.
FACIES/DEP. ENVIRONMENT
28 boxes of 3' each
Total thickness: 56'
Hwy/Nordegg 6130' E
COMMENTS
Bioclastic sandstone. More and bigger elongated shells at the base. Glauconite grains. Full of Do Crystal. Inch mark the real fine grain size. Grey shaly silt laminae (# laminae @) It's bioclastic at the base and apparently just clastic at the top
Good unit 24 m
Isolated patches with a whole bunge of voggs. (Big ones) → 5 mm. Fy in the walls of the individual voggs
10 to 21 m
A little big wavy at the base and truly # laminated toward the top
Burrows: Anteosoma? in the thicker shales at the base; Small round a / cylindrical Escape burrows
EROSIVE CONTACT
Top NT
This unit is sandier than 1 but rep the same characteristics
Fy in rounded patches sometimes dismembered and sometimes concentrated in levels
Small not well developed Rosselia/Cylindrichnus
Burrows: In sandstone and some "infill" with dolomite. Some of them have a pustular lining. Shape like planolites. Teichichnus and // straight open burrows
sand — shaly silt
2 — 1a — 1
1st appearance of "Teichichnus" or not least open burrows.
Do crystal and Do patches
OFFSHORE TRANSITION to LOWER SHOREFACE
B/C
Interbedded: bottom VFL Sand and Grey silty shale it's more straight laminated this way
Burrowed Planolites, escape burrows
Some burrows infill with Do, some in sandstone
No living
B
LOWER SHOREFACE
C
Interbedded: between VFL Sandstone and grey shaly silt
Do Crystals. Patches of Fy. Straight Planolites (grey)
A lot of burrowing → planolites, chondrites ??
Complex net.
B

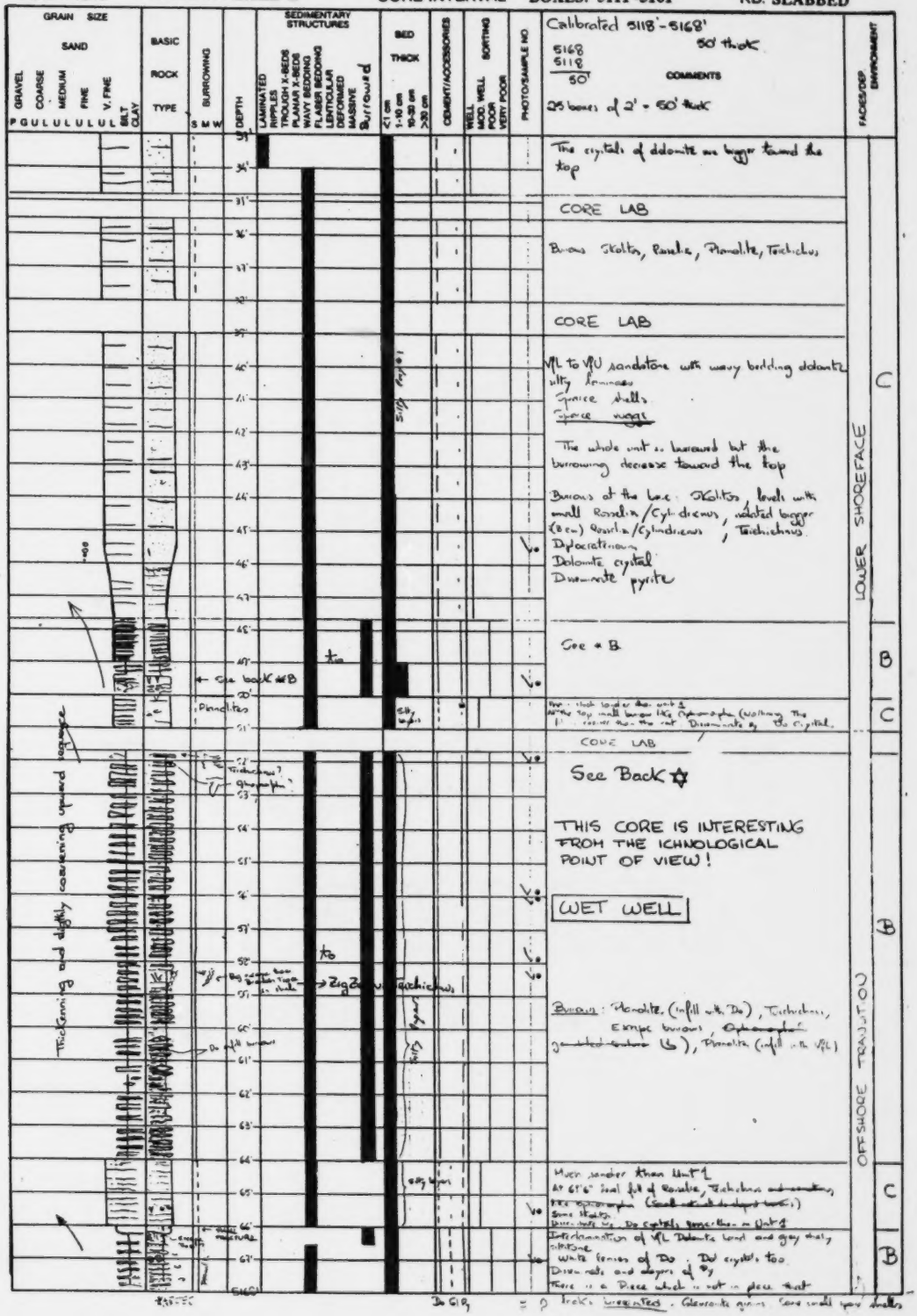
WELL NAME: 15-18-68-21W5(2OF 2) FORMATION: MONTNEY DATE: SEPT. 21, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL BOXES: 5119'-5174' CALIBRATED: 5120'-5176' SLABBED



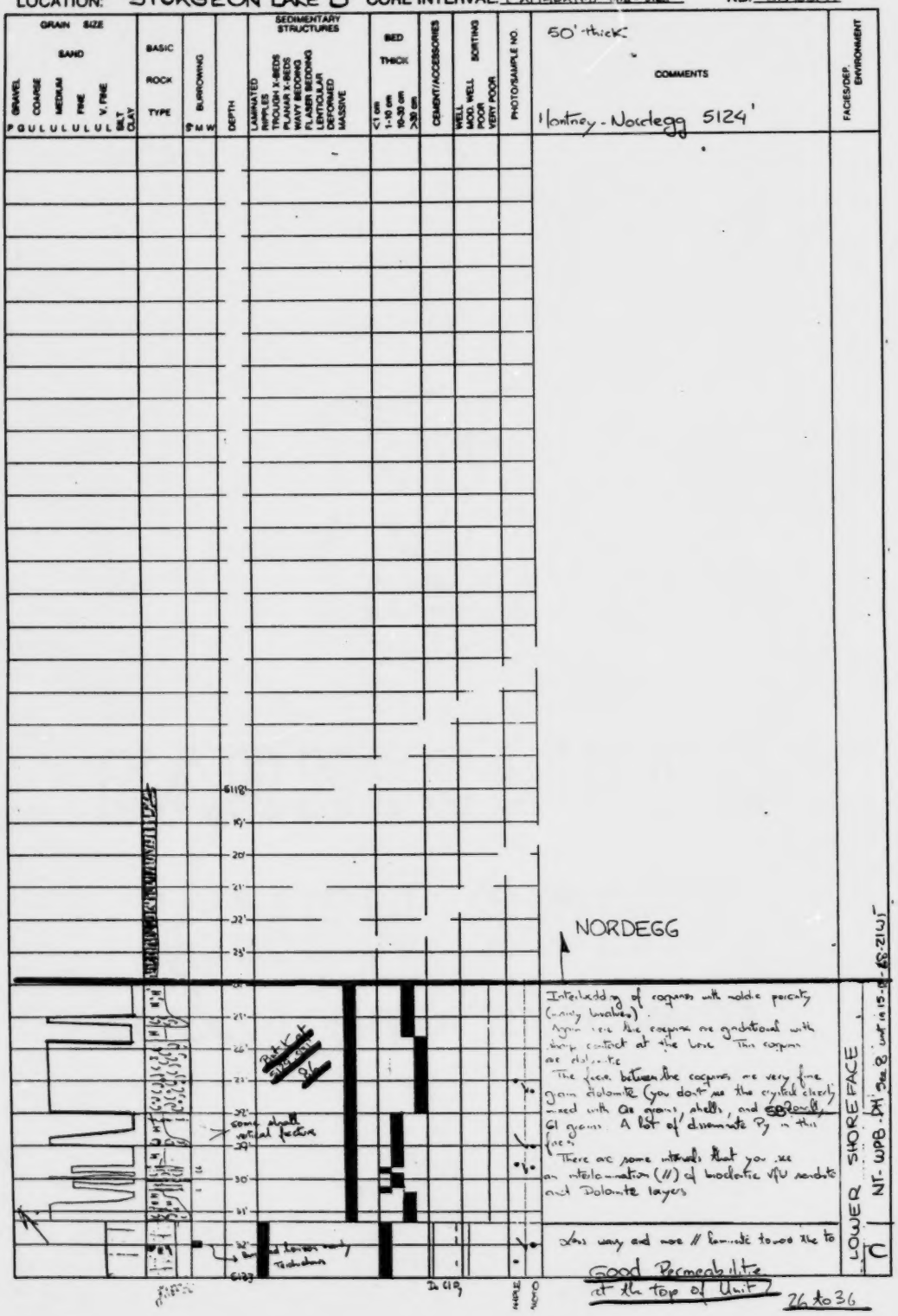
WELL NAME: 3-19-68-21W5 (1 OF 2) FORMATION: MONTNEY DATE: SEPT. 22, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL BOXES: 5111'-5161' KB: SLABBED



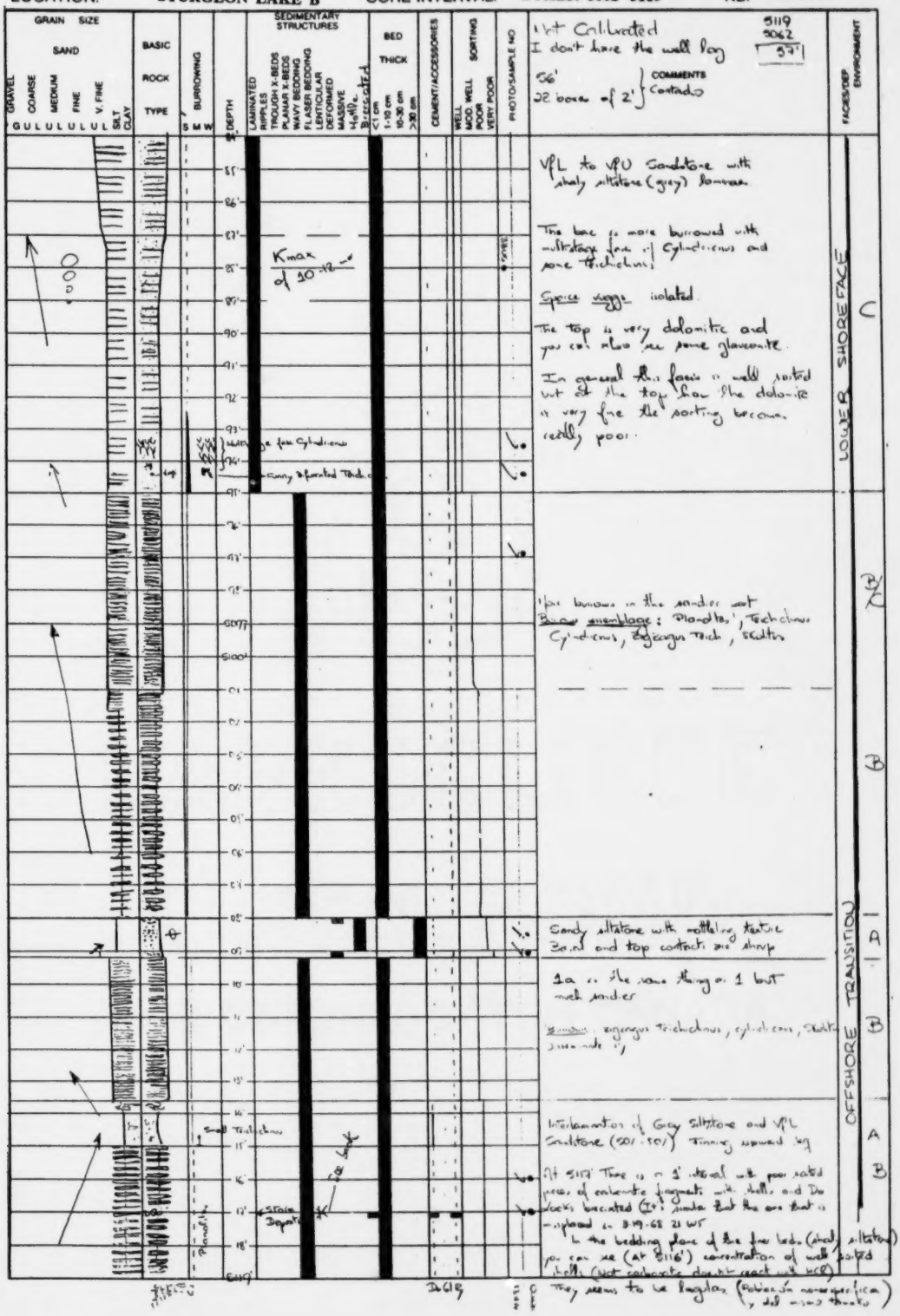
WELL NAME: 3-19-68-21W5 (2 OF 2) FORMATION: MONTNEY DATE: 22 Sept 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: From the Logs 5111 - 5161 CALIBRATED 5118 - 5168' KB: SLABBED



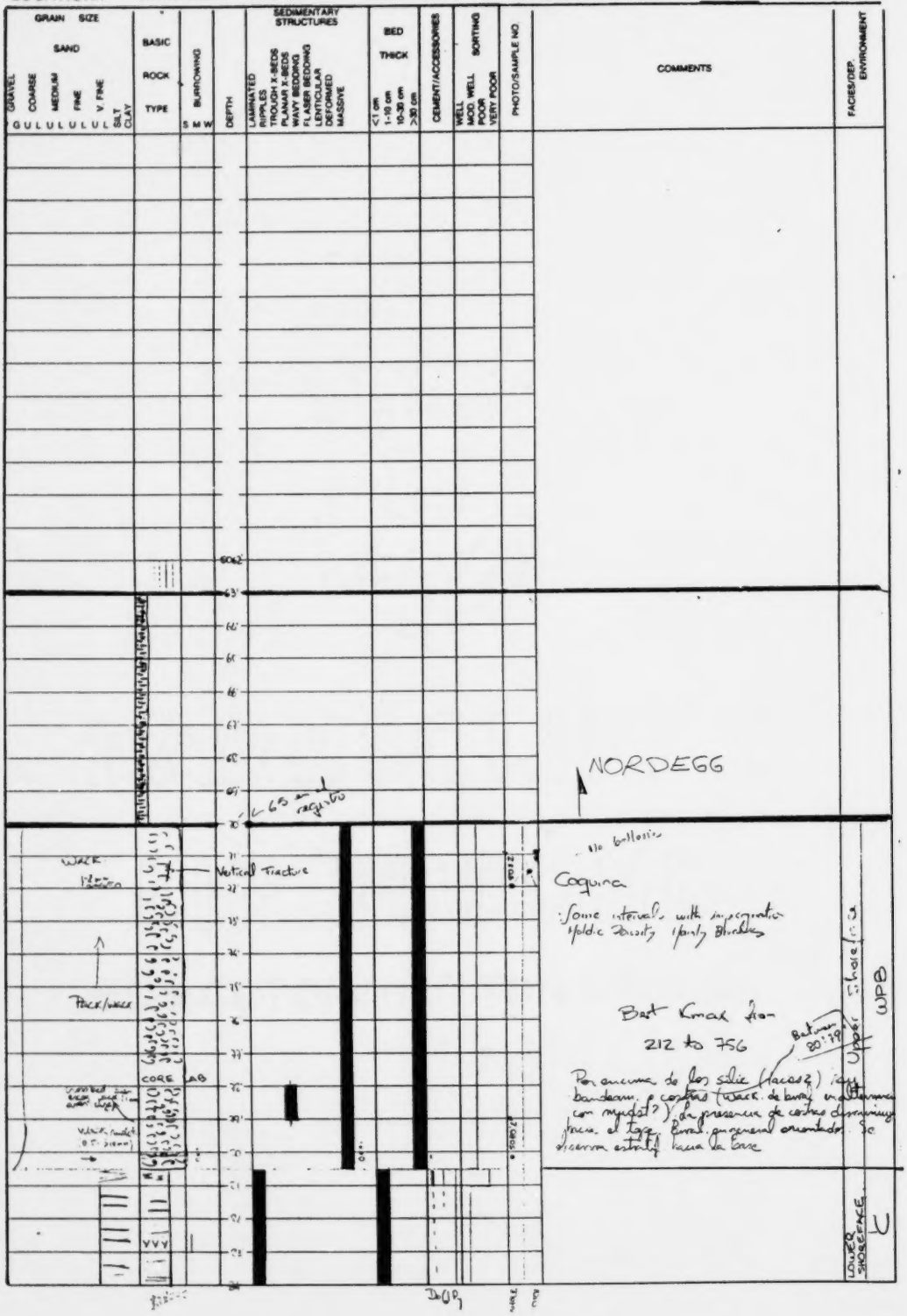
WELL NAME: 5-19-68 -21W5 (1 OF 2) FORMATION: MONTNEY-NORDEGG DATE: SEPT. 27, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5062'-5119' KB: SLABBED



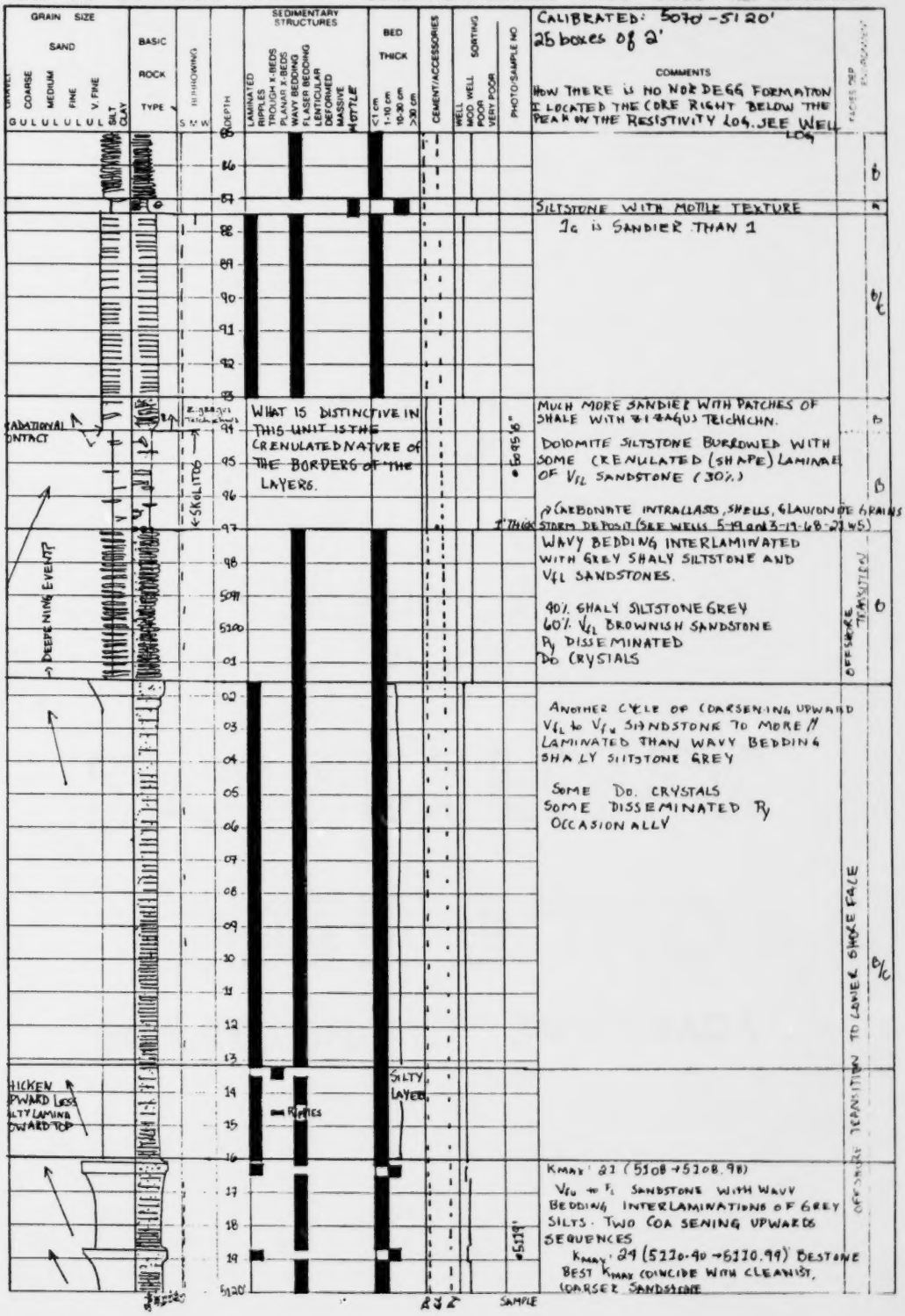
WELL NAME: 5-19-68 -21W5 (OF 2) FORMATION MONTNEY-NORDEGG DATE: SEPT. 27, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5062'-5119' KB: SLABBED



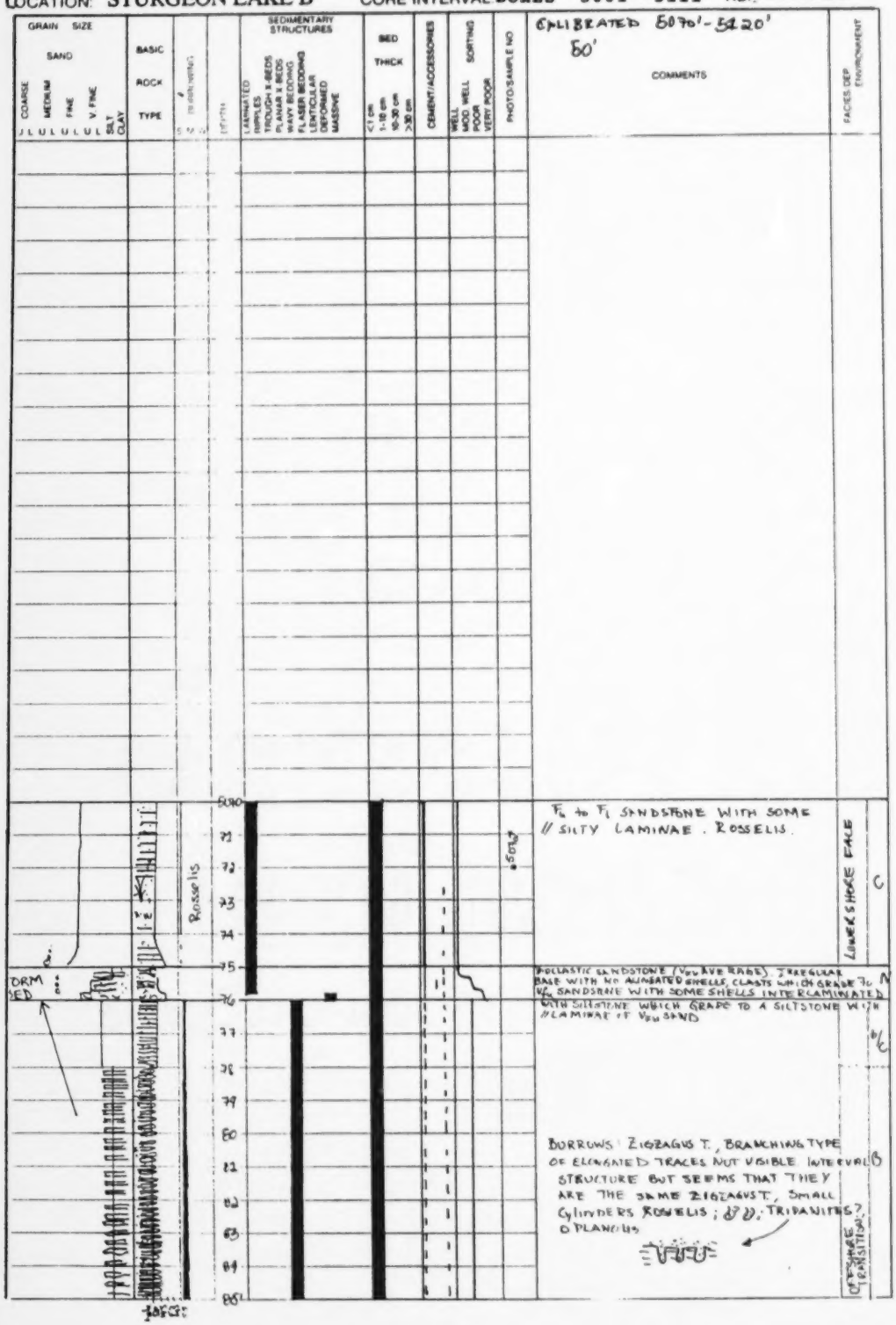
WELL NAME 11-19-68-21W5 (1 OF 2) FORMATION: MONTNEY DATE SEPT. 27, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5061'-5111' KB: SLABBED


GRAIN SIZE
SAND
GRAVEL COARSE MEDIUM FINE V. FINE SILT CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED RIPPLES TROUGH X-BEDS PLANAR X-BEDS WAVY BEDDING FLASER BEDDING LENTICULAR DEFORMED MASSIVE MOTTLE
BED THICK
<1 cm 1-10 cm 10-30 cm >30 cm
CEMENT/ACCESSORIES
SORTING
WELL MOD WELL POOR VERY POOR
PHOTO/SAMPLE NO
CALIBRATED: 5070-5120'
25 boxes of 2'
COMMENTS
HOW THERE IS NO NOR DEGG FORMATION I LOCATED THE CORE RIGHT BELOW THE PEAK ON THE RESISTIVITY LOG. SEE WELL LOG
FACIES DEP ENV
SILTSTONE WITH MOTTLE TEXTURE
Ig is SANDIER THAN 1
MUCH MORE SANDIER WITH PATCHES OF SHALE WITH Z. BIFAGUS TEICHICHN.
DOLOMITE SILTSTONE BURROWED WITH SOME (CRENULATED (SHAPE) LAMINAE OF VFL SANDSTONE (30%)
CARBONATE INTRACLASTS, SHELLS, GLAUCONITE GRAINS
STORM DEPOSIT (SEE WELLS 5-19 and 3-19-68-21W5)
WHAT IS DISTINCTIVE IN THIS UNIT IS THE CRENULATED NATURE OF THE BORDERS OF THE LAYERS.
SIDERITE
SKOLITOS
DEEPENING EVENT?
WAVY BEDDING INTERLAMINATED WITH GREY SHALY SILTSTONE AND VFL SANDSTONES.
90% SHALY SILTSTONE GREY
60% VFL BROWNISH SANDSTONE
Py DISSEMINATED
Do CRYSTALS
OFFSHORE TRANSITION
ANOTHER CYCLE OF COARSENING UPWARD VFL to VFU SANDSTONE TO MORE // LAMINATED THAN WAVY BEDDING SHALY SILTSTONE GREY
SOME Do. CRYSTALS
SOME DISSEMINATED Py
OCCASIONALLY
TO LOWER SHORE FACE
THICKEN UPWARD LESS SILTY LAMINA DOWARD TOP
RIPPLES
SILTY LAYER
KMAX: 21 (5108-5108.98)
VFU to FL SANDSTONE WITH WAVY BEDDING INTERLAMINATIONS OF GREY SILTS. TWO COARSENING UPWARDS SEQUENCES
KMAX: 29 (5110.90-5110.99) BESTONE BEST KMAX COINCIDE WITH CLEANEST, COARSEST SANDSTONE
OFFSHORE TRANSITION
SAMPLE

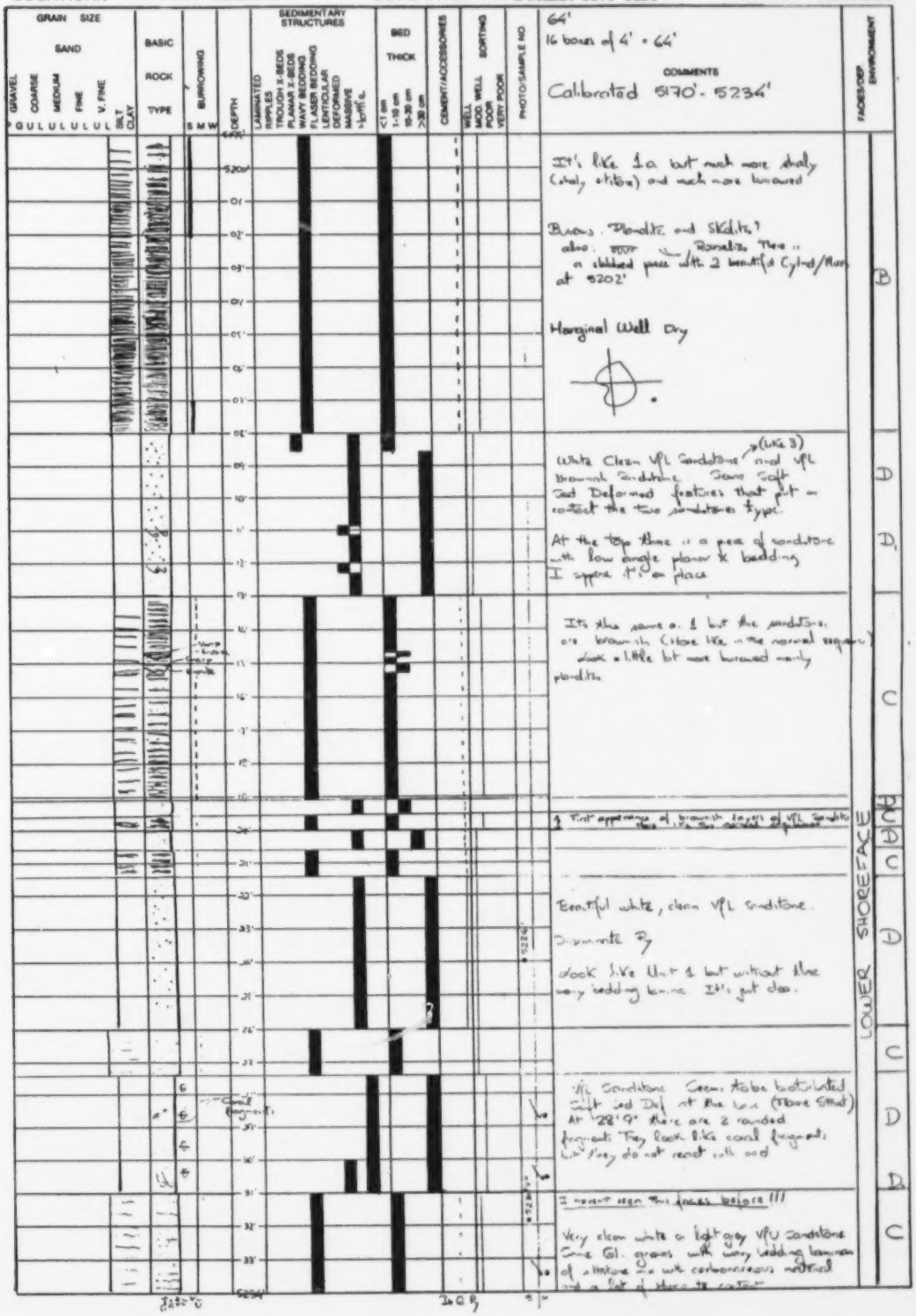
WELL NAME: 11-19-68-21W5 (2 OF 2) FORMATION: MONTNEY DATE: SEPT. 27, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5061'-5111' KB: SLABBED



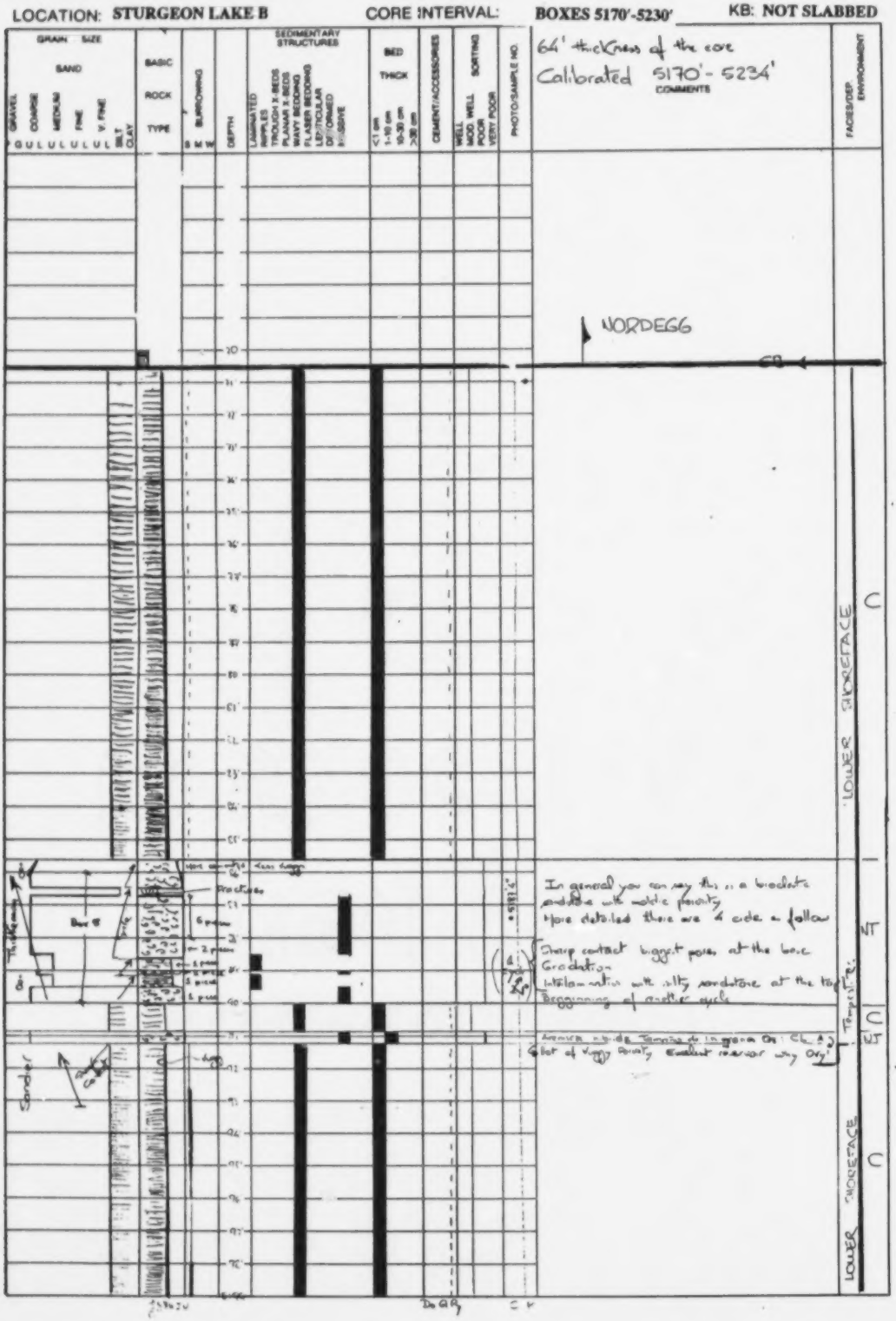
WELL NAME: 7-26-68-21W5 (1 OF 2) FORMATION: MONTNEY DATE: SEPT. 28, 1994

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5170'-5230' KB: NOT SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
S M W
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD. WELL
POOR
VERY POOR
PHOTO/SAMPLE NO
64'
16 boxes of 4' = 64'
COMMENTS
Calibrated 5170' - 5234'
FACIES/DEP ENVIRONMENT
It's like 1a but much more shaly (shaly siltst) and much more burrowed
Burrows - Planolites and Skolithos?
also: ??? Rosselia ??
a slabbed piece with 2 beautiful Cylindrichnus at 5202'
Marginal Well Dry
White Clean VFL Sandstone (Like 3) mod VFL Brownish Sandstone Some Soft Sed Deformed features that juxt - contact the two sandstone types
At the top there is a piece of sandstone with low angle planar X bedding I suppose it's in place
It's the same as 1 but the sandstone are brownish (More like in the normal sequence) dark a little bit more burrowed mainly planolites
1 First appearance of brownish layers of VFL Sandstone
Beautiful white, clean VFL sandstone.
Dominantly
dark Silt Unit 1 but without the wavy bedding laminae It's just clean.
VFL Sandstone Seems to be bioturbated Silt sed Def at the top (Flame Structures) At 5228'9" there are 2 rounded fragments They look like coal fragments but they do not react with acid
I noticed this process before !!!
Very clean white to light gray VFL Sandstone Some Gl. grains with wavy bedding laminae of siltstone Some carbonaceous material and a bit of bioturbation
LOWER SHOREFACE
A
A1
C
HAC
A
U
D
D
C

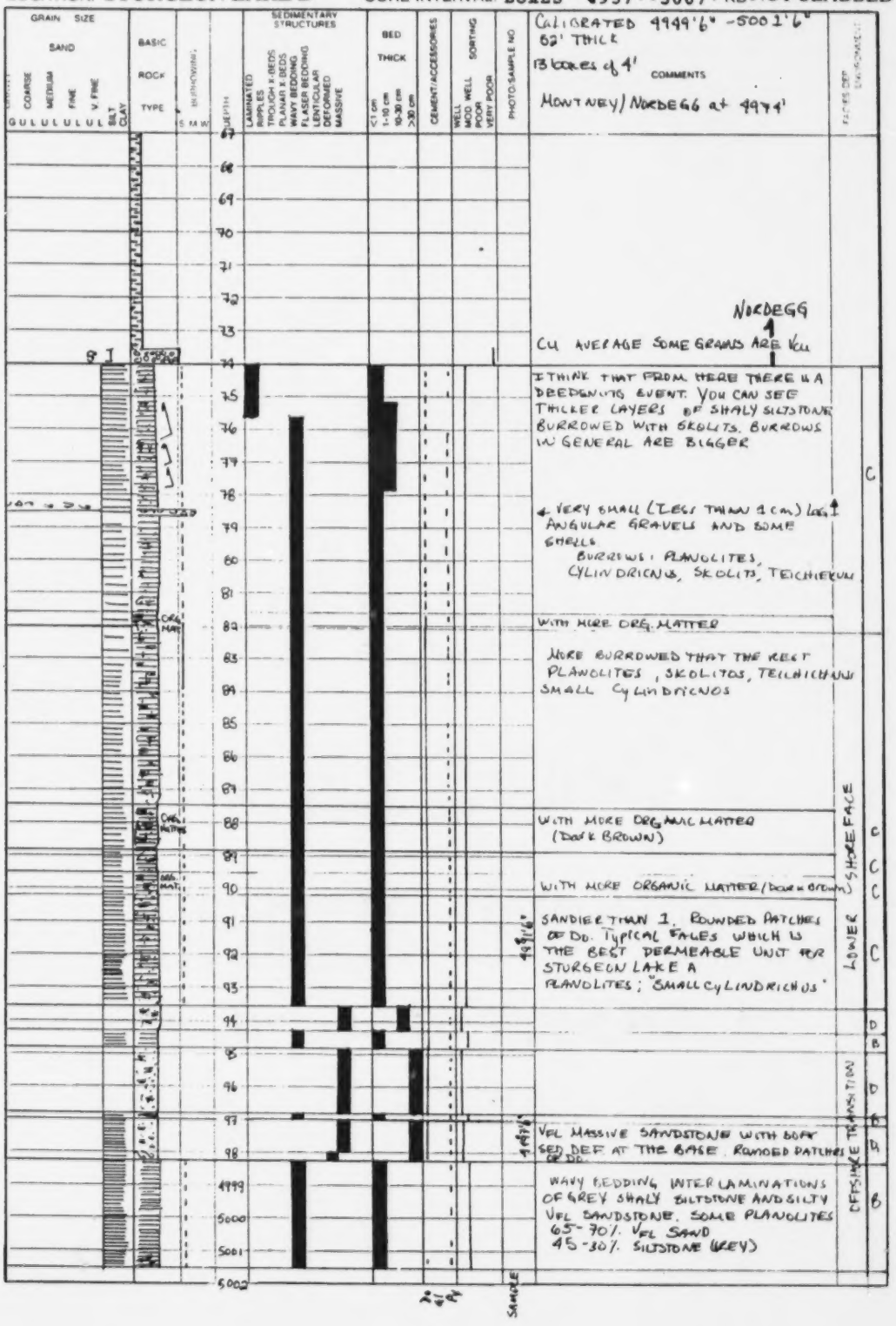
WELL NAME: 7-26-68-21W5 (2 OF 2) FORMATION: MONTNEY DATE: SEPT. 28, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5170'-5230' KB: NOT SLABBED



WELL NAME: 5-32-68-21W5 (1 OF 2) FORMATION: MONTNEY DATE SEPT. 30, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 4957'-5007' KB NOT SLABBED



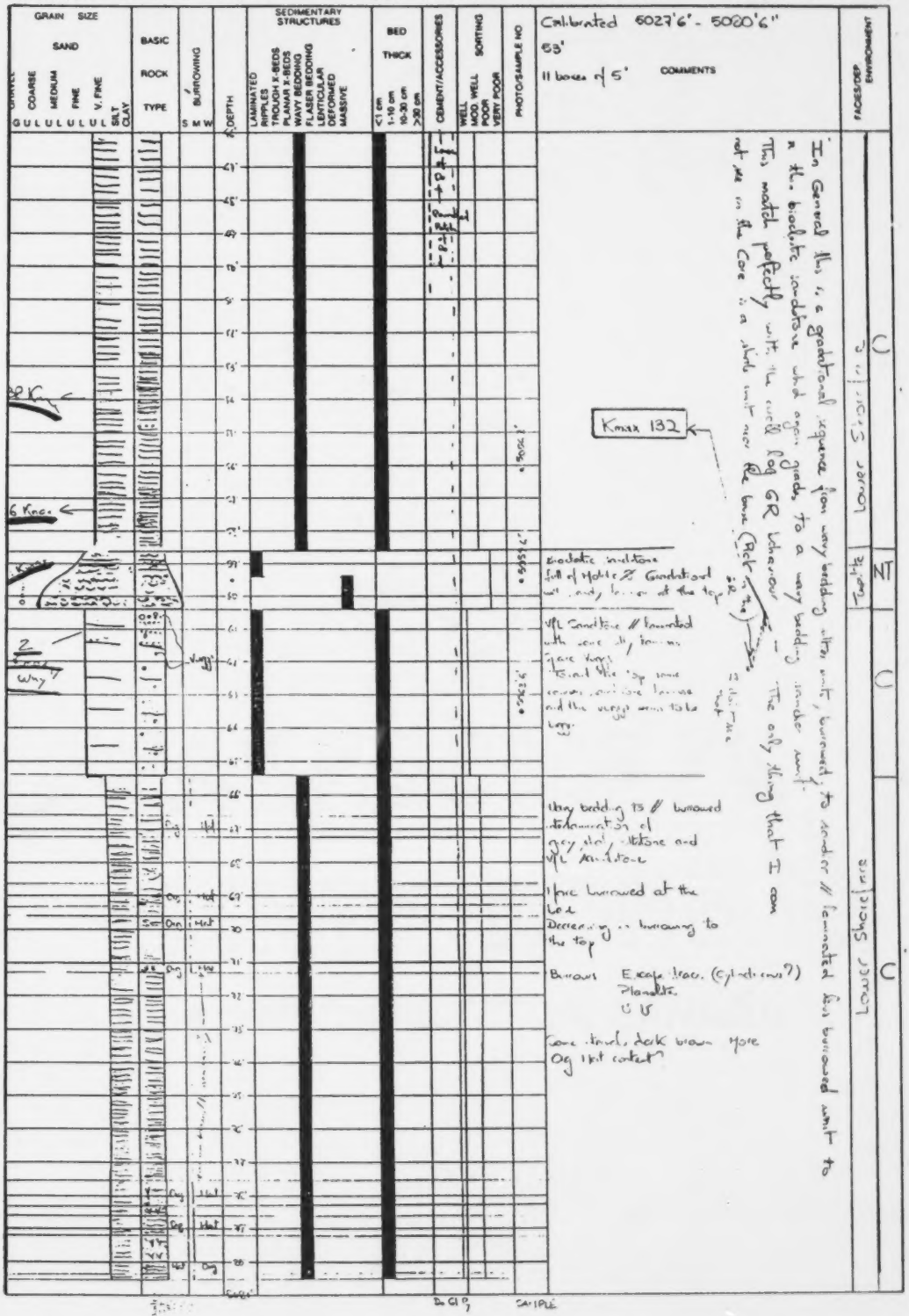
WELL NAME: 5-32-68-21W5 (2 OF 2) FORMATION: MONTNEY DATE SEPT. 30, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 4957'-5007' KB NOT SLABBED

GRAIN SIZE (GRAVEL, COARSE, MEDIUM, FINE, V FINE, SILT, CLAY)	BASIC ROCK TYPE	DEPTH	SEDIMENTARY STRUCTURES (LAMINATED, TROUGH X BEDS, PLANAR X BEDS, WAVY BEDDING, FLASER BEDDING, LENTICULAR, DEFORMED, MASSIVE)	BED THICK (<1 cm, 1-10 cm, 10-30 cm, >30 cm)	CEMENT/ACCESSORIES	SORTING (WELL, MOD, POOR, VERY POOR)	PHOTO/SAMPLE NO	COMMENTS	DEPTH ENVIRONMENT
								CALIBRATED 4999'6" - 5001'6"	
		49							
		50							
		51							
		52							
		53							
		54							
		55							
		56							
		57							
		58							
		59							
		60							
		61							
		62							
		63							
		64							
		65							
		66							
		67							

WELL NAME: **13 36 68 21W5(1)** FORMATION: **MONTNEY** DATE: **OCT. 1, 1993**

LOCATION: **STURGEON LAKE B** CORE INTERVAL: **BOXES 5028'-5078'** KB: **NOT SLABBED**



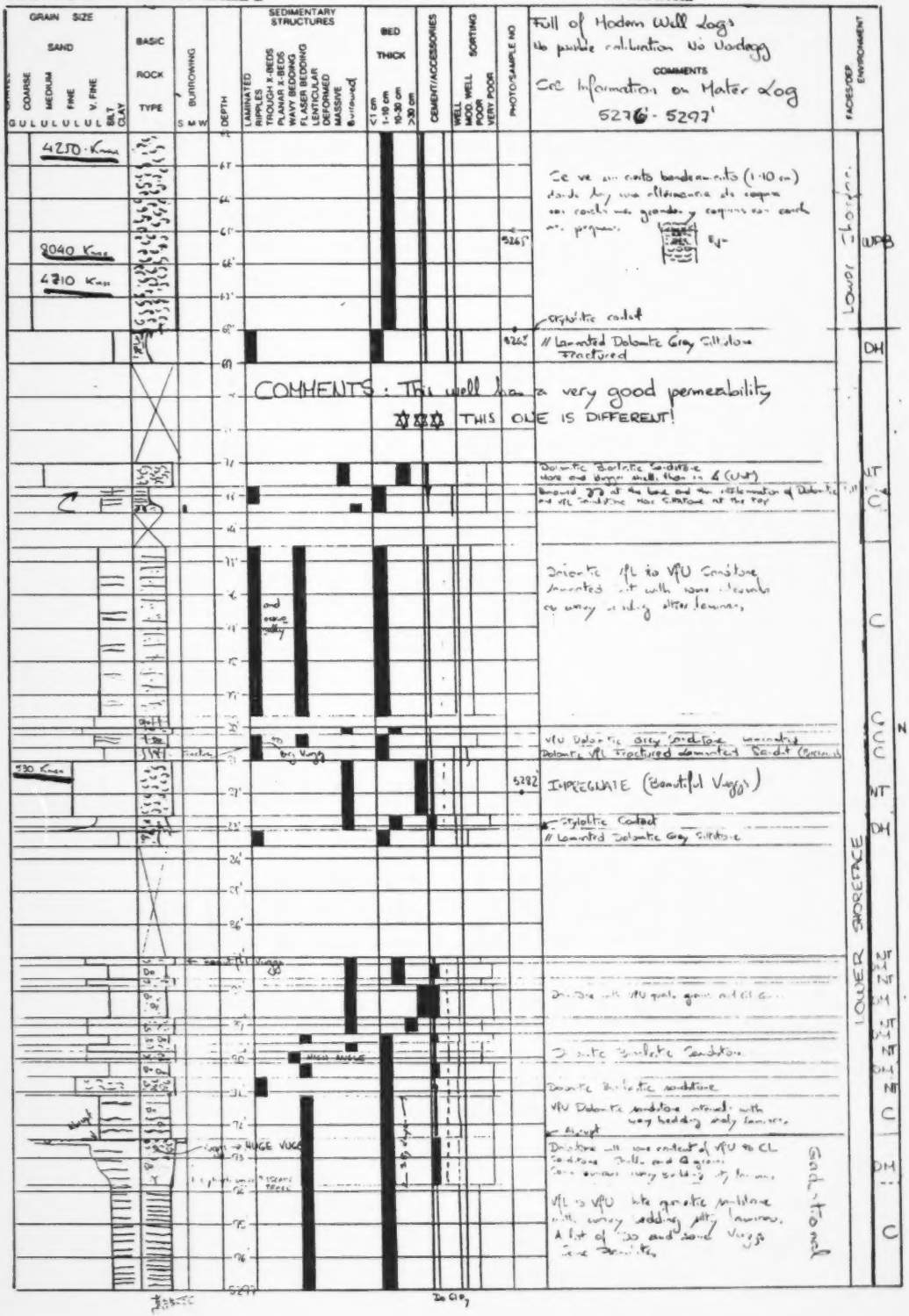
121

WELL NAME **13 36 68 21W5(2)** FORMATION: MONTNEY DATE: OCT. 1, 1993

LOCATION: STUGEON LAKE B CORE INTERVAL: BOXES 5028'-5078' KB: NOT SLABBED

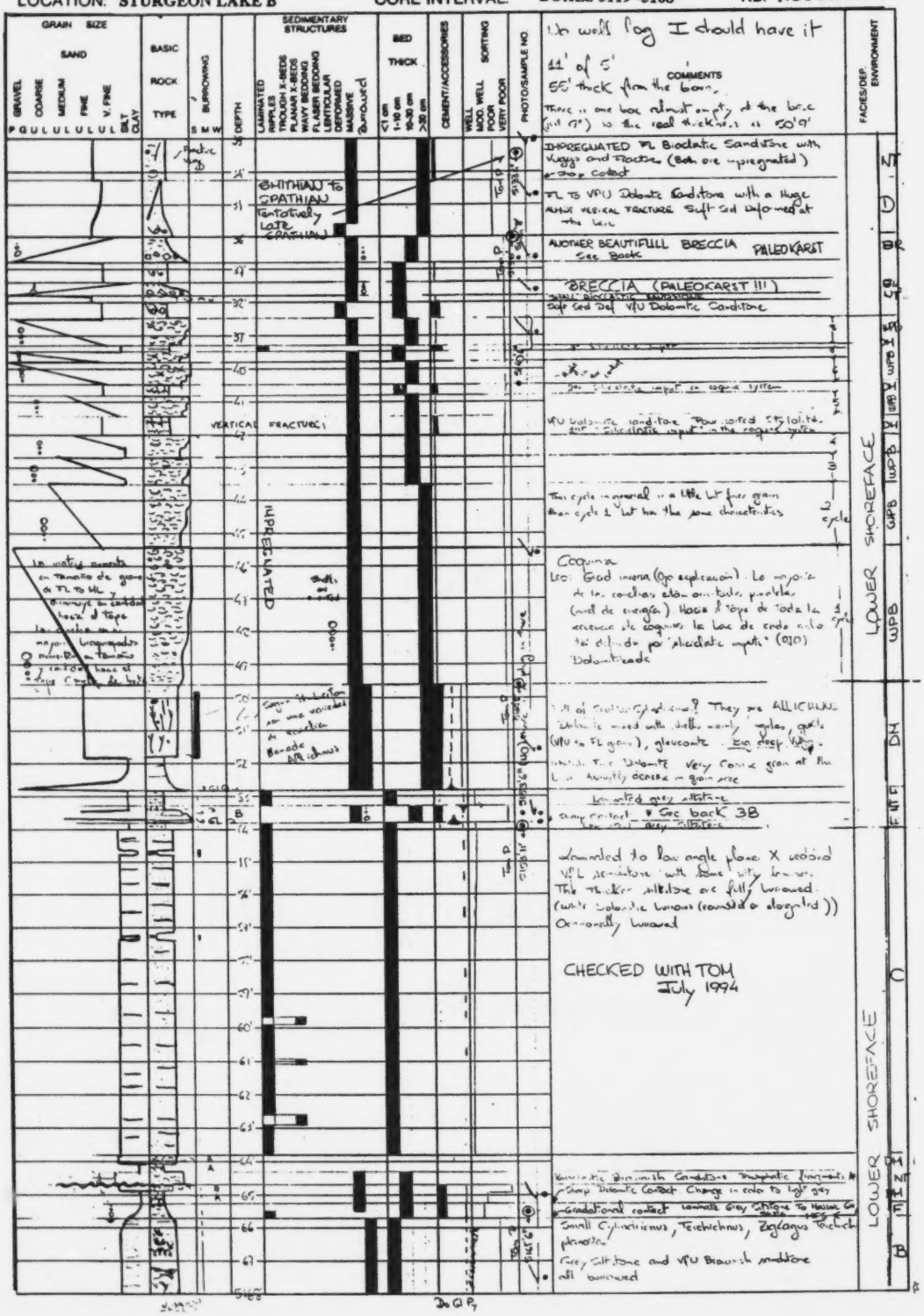
WELL NAME: **14-10-68-22W5 (1 OF 1)** FORMATION: **MONTNEY** DATE: **OCT. 5, 1993**

LOCATION: **STURGEON LAKE B** CORE INTERVAL: **BOXES: 1607m-1614.40m** KB: **NOT SLABBED**



WELL NAME: 3-23-68-22W5 (1 OF 2) FORMATION: MONTNEY DATE: OCT. 6, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5119'-5168' KB: NOT SLABBED

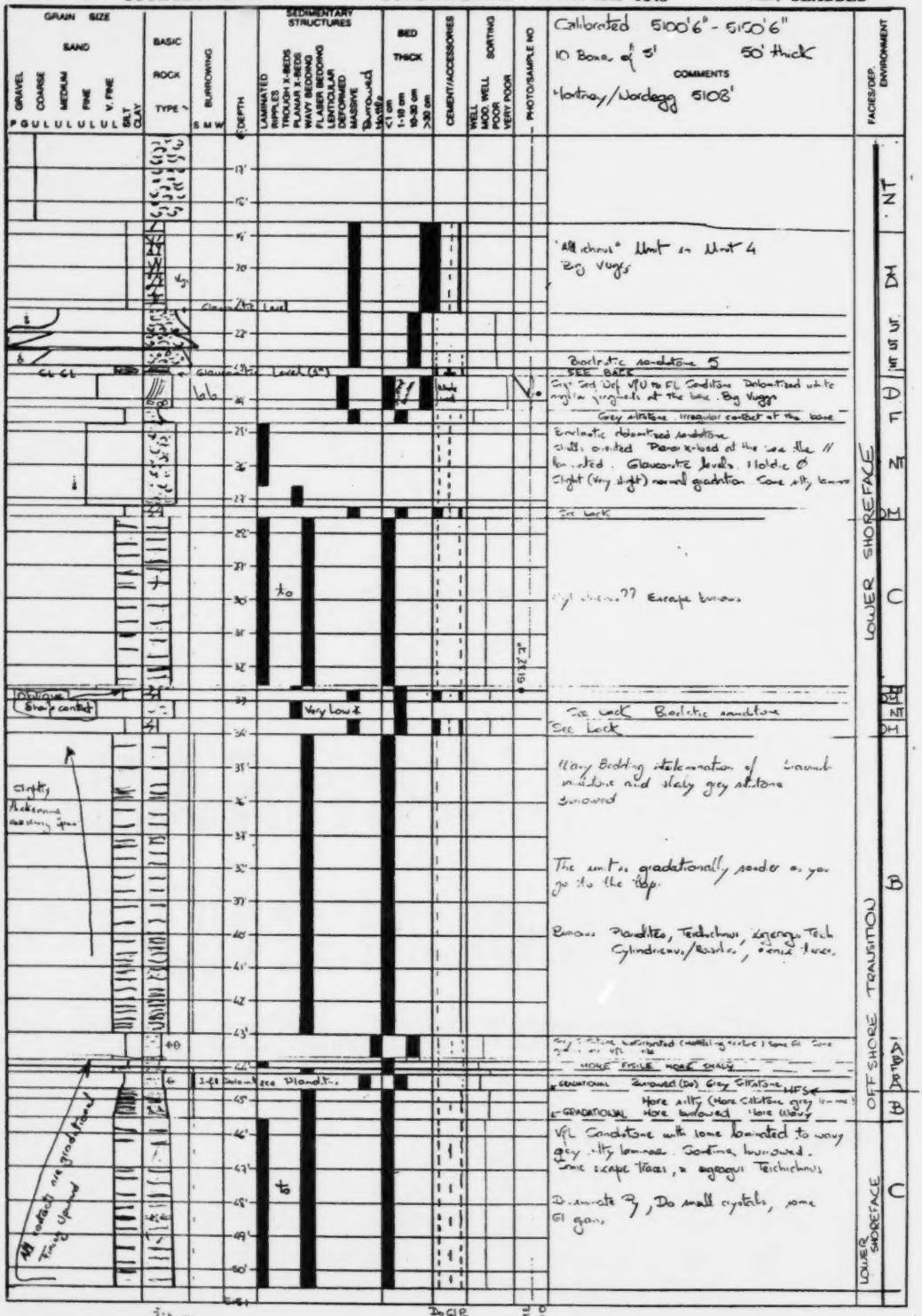


WELL NAME: 3-23-68-22W5 (2 OF 2) FORMATION: MONTNEY DATE: OCT. 6, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL BOXES 5119'-5168' KB: NOT SLABBED

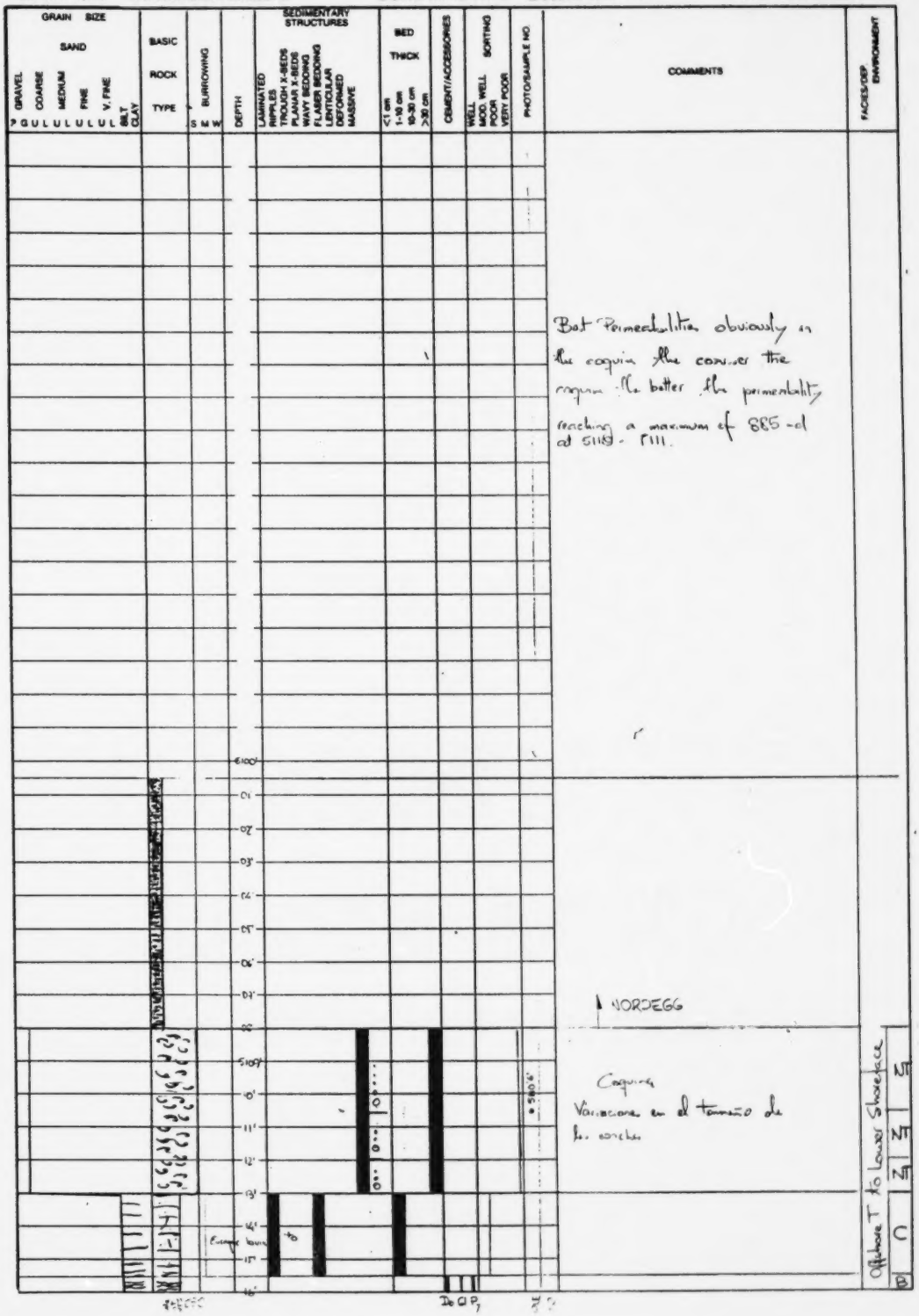
WELL NAME: 02/ 7-23-68-22W5 (1 OF 2) FORMATION: MONTNEY DATE: OCT. 8, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5103'-5148' KB:. SLABBED



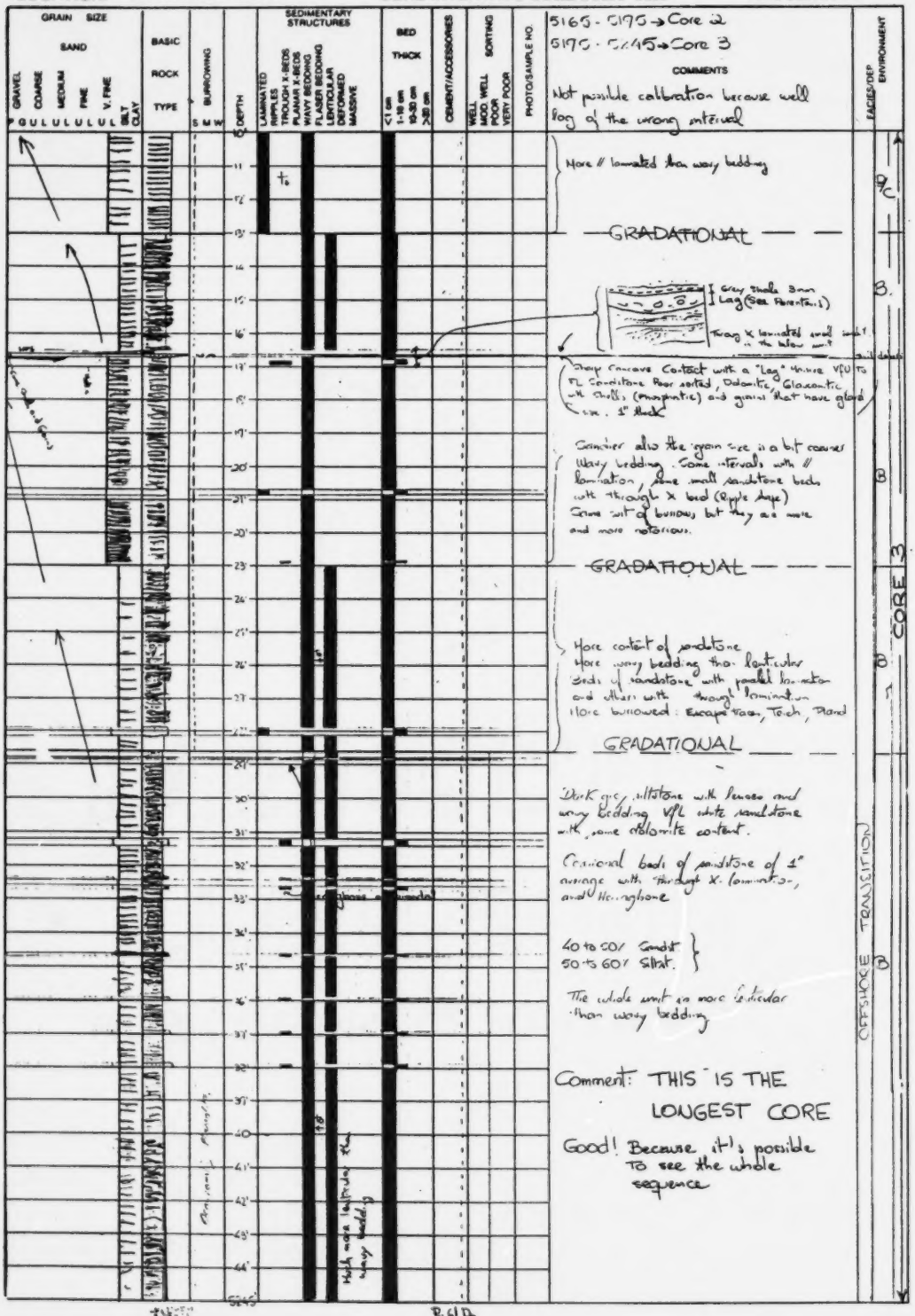
WELL NAME: 02/ 7-23-68-22W5 (2 OF 2) FORMATION: MONTNEY DATE: OCT. 8, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES 5103'-5148' KB: SLABBED



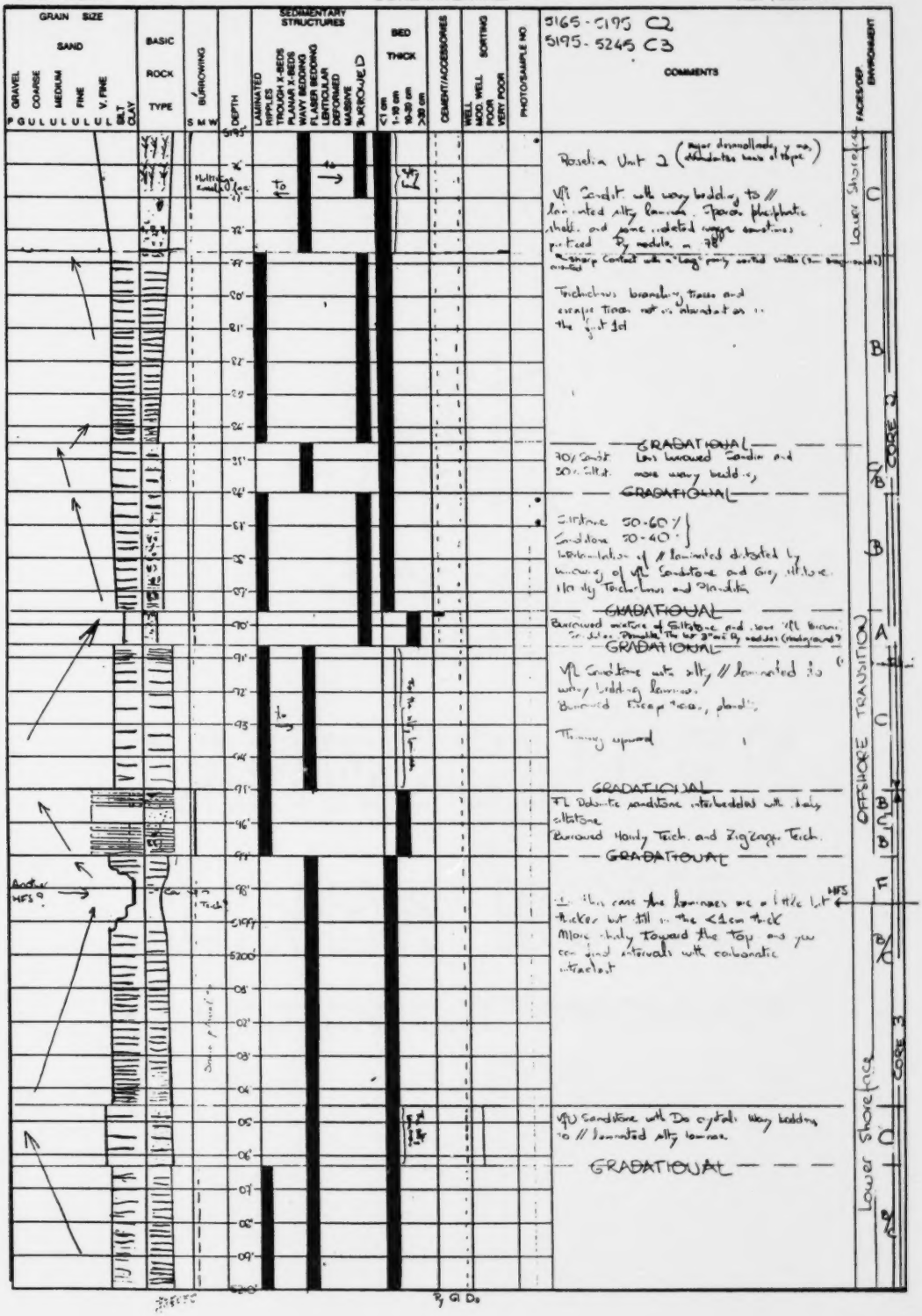
WELL NAME: 3-24-68-22W5 (1 OF 4) FORMATION: MONTNEY DATE: OCT. 12, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: CORE 1 5130'-5165' KB: SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BED THICK
CEMENT/ACCESSORIES
SORTING
WELL
MOD. WELL
POOR
VERY POOR
PHOTO/SAMPLE NO.
5165 - 5175 → Core 2
5175 - 5145 → Core 3
COMMENTS
Not possible calibration because well flog of the wrong interval
FACIES/DEP ENVIRONMENT
More // laminated than wavy bedding
GRADATIONAL
Gray shale 3mm Lag (See Porcellanite)
Wavy X laminated sand unit in the lower unit
Wavy Concave Contact with a "Lag" thinner VFU to FL Sandstone Poor sorted, Dolomitic, Glauconitic with Shells (marginatic) and grains that have glaze 1cm. 1" thick
Somewhere also the grain size is a bit coarser Wavy bedding. Some intervals with // laminations, some small sandstone beds with through X bed (Ripple shape) Some unit of burrows, but they are more and more notorious.
GRADATIONAL
More content of sandstone More wavy bedding than lenticular beds of sandstone with parallel lamination and others with through lamination More burrowed: Escape trace, Teich, Planol
GRADATIONAL
Dark grey siltstone with lenses and wavy bedding V/FL white sandstone with some dolomite content.
Occasional beds of sandstone of 1" average with through X-lamination and Hummocky
40 to 50% Sandst
50 to 60% Siltst.
The whole unit are more // bedded than wavy bedding
Comment: THIS IS THE LONGEST CORE
Good! Because it's possible to see the whole sequence
OFFSHORE TRANSITION
CORE 3

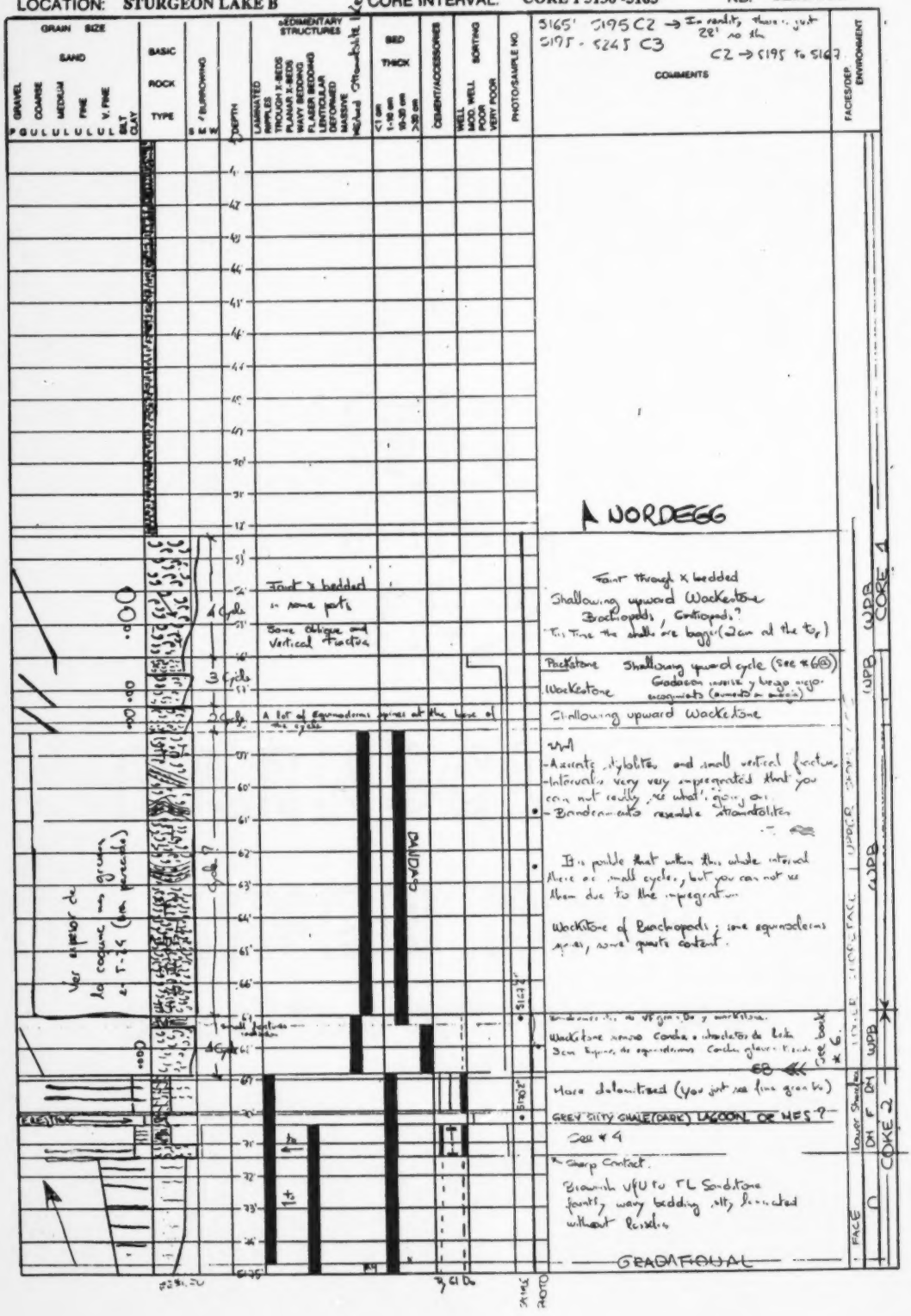
WELL NAME: 3-24-68-22W5 (2 OF 4) FORMATION: MONTNEY DATE: OCT. 12, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: CORE 1 5130'-5165' KB: SLABBED



WELL NAME: 3-24-68-22W5 (3 OF 4) FORMATION: MONTNEY DATE: OCT. 13, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: CORE 1 5130'-5165' KB: SLABBED



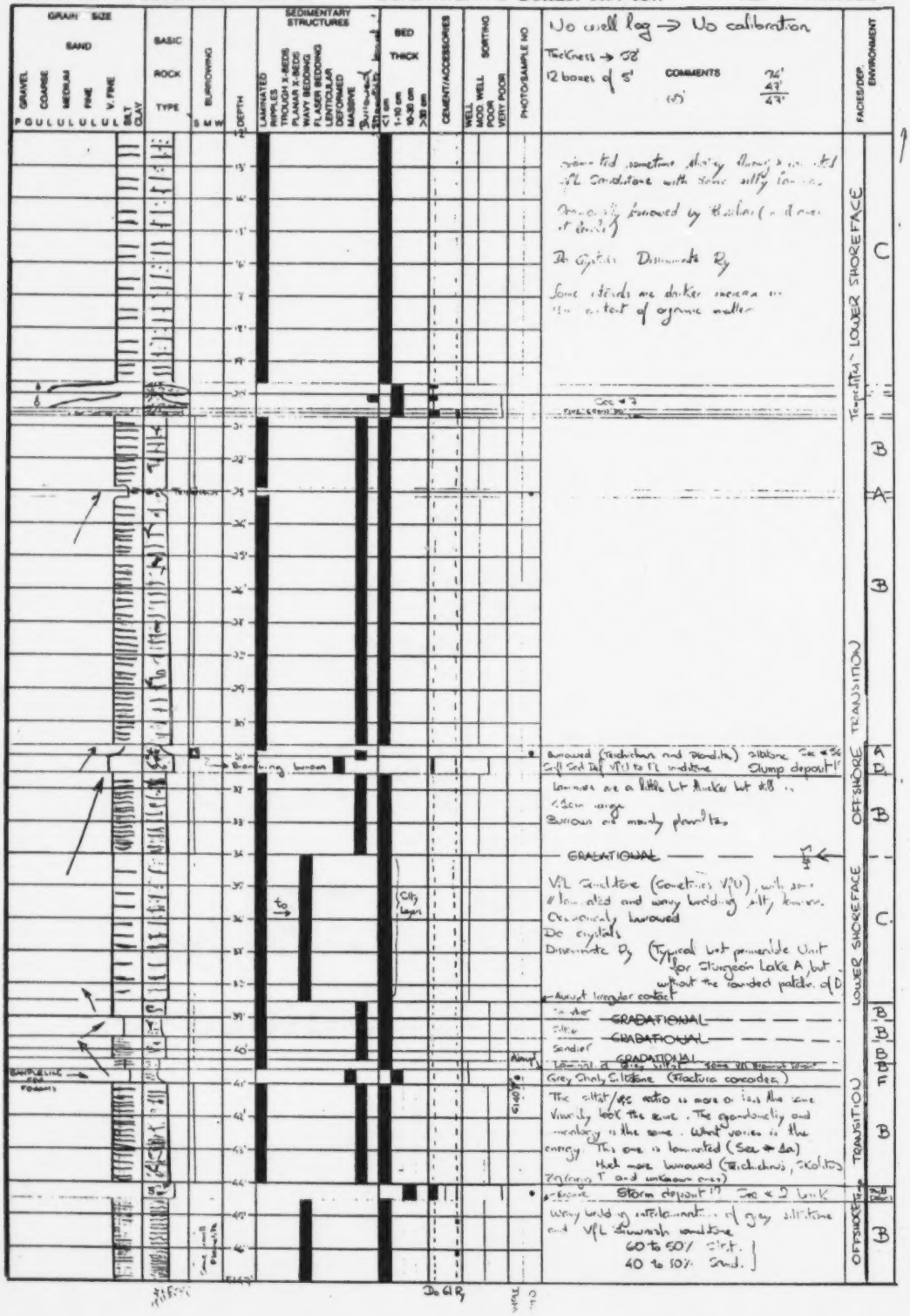
WELL NAME: 3-24-68-22W5 (4 OF 4) FORMATION: MONTNEY DATE: OCT. 12, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: CORE 1 5130'-5165' KB: SLABBED

GRAIN SIZE: GRAVEL (P)	SAND: COARSE (G)	SAND: MEDIUM (U)	SAND: FINE (L)	SAND: V. FINE (U)	SAND: SILT (L)	CLAY (U)	BASIC ROCK TYPE	BURROWING: B	BURROWING: M	BURROWING: W	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED	SEDIMENTARY STRUCTURES: RIPPLES	SEDIMENTARY STRUCTURES: TROUGH X-BEDS	SEDIMENTARY STRUCTURES: PLANAR X-BEDS	SEDIMENTARY STRUCTURES: WAVY BEDDING	SEDIMENTARY STRUCTURES: FLASER BEDDING	SEDIMENTARY STRUCTURES: LENTICULAR	SEDIMENTARY STRUCTURES: DEFORMED	SEDIMENTARY STRUCTURES: MASSIVE	BED THICK: <1 cm	BED THICK: 1-10 cm	BED THICK: 10-30 cm	BED THICK: >30 cm	CEMENT/ACCESSORIES	SORTING: WELL	SORTING: MOD. WELL	SORTING: POOR	SORTING: VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES/DEP. ENVIRONMENT
																																5165-5195 C2 5195-5245 C3 5245 5130 115'	

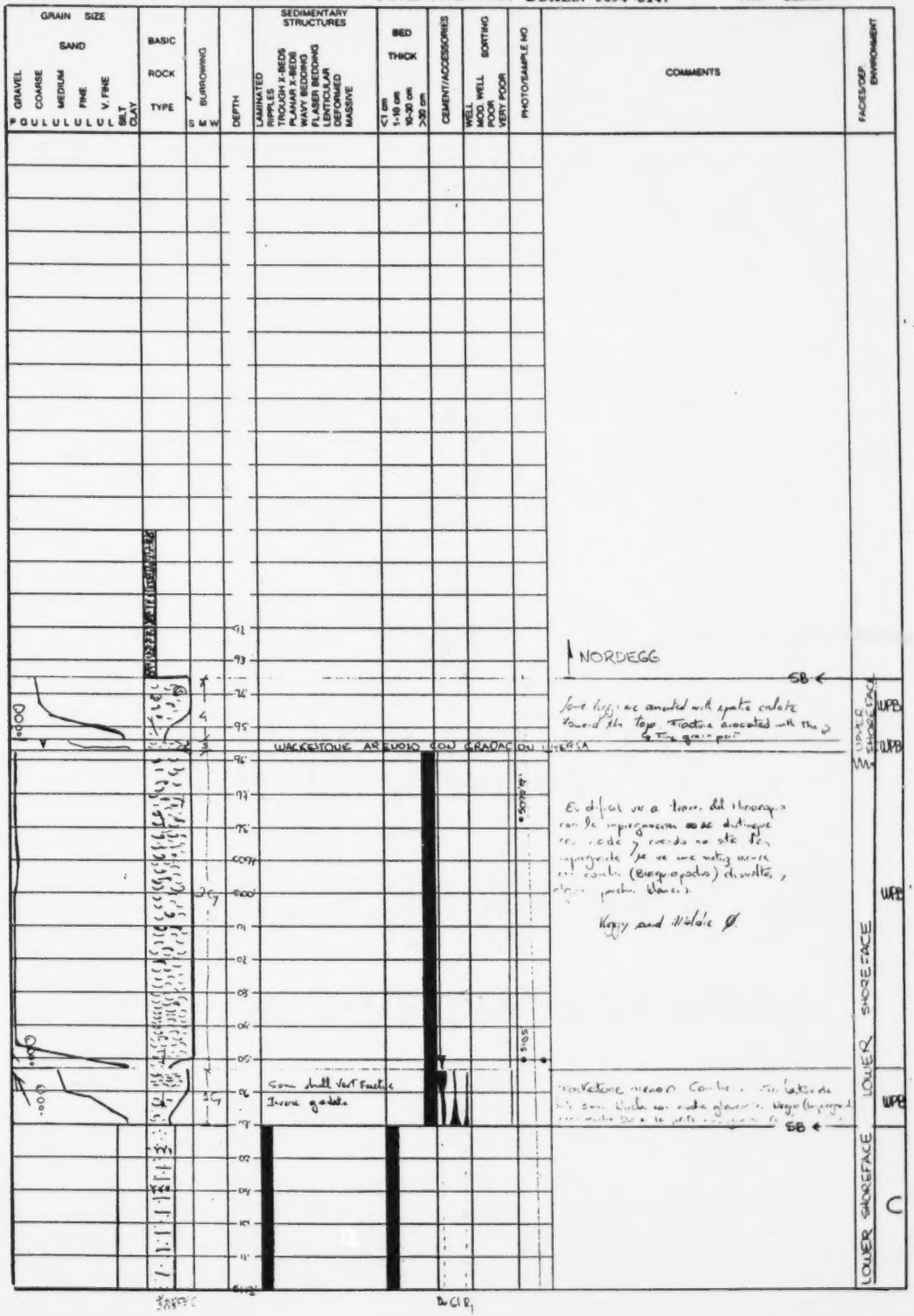
WELL NAME: 5-24-68-22W5 (1 OF 2) FORMATION: MONTNEY DATE: OCT. 14, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5094'-5147' KB: SLABBED



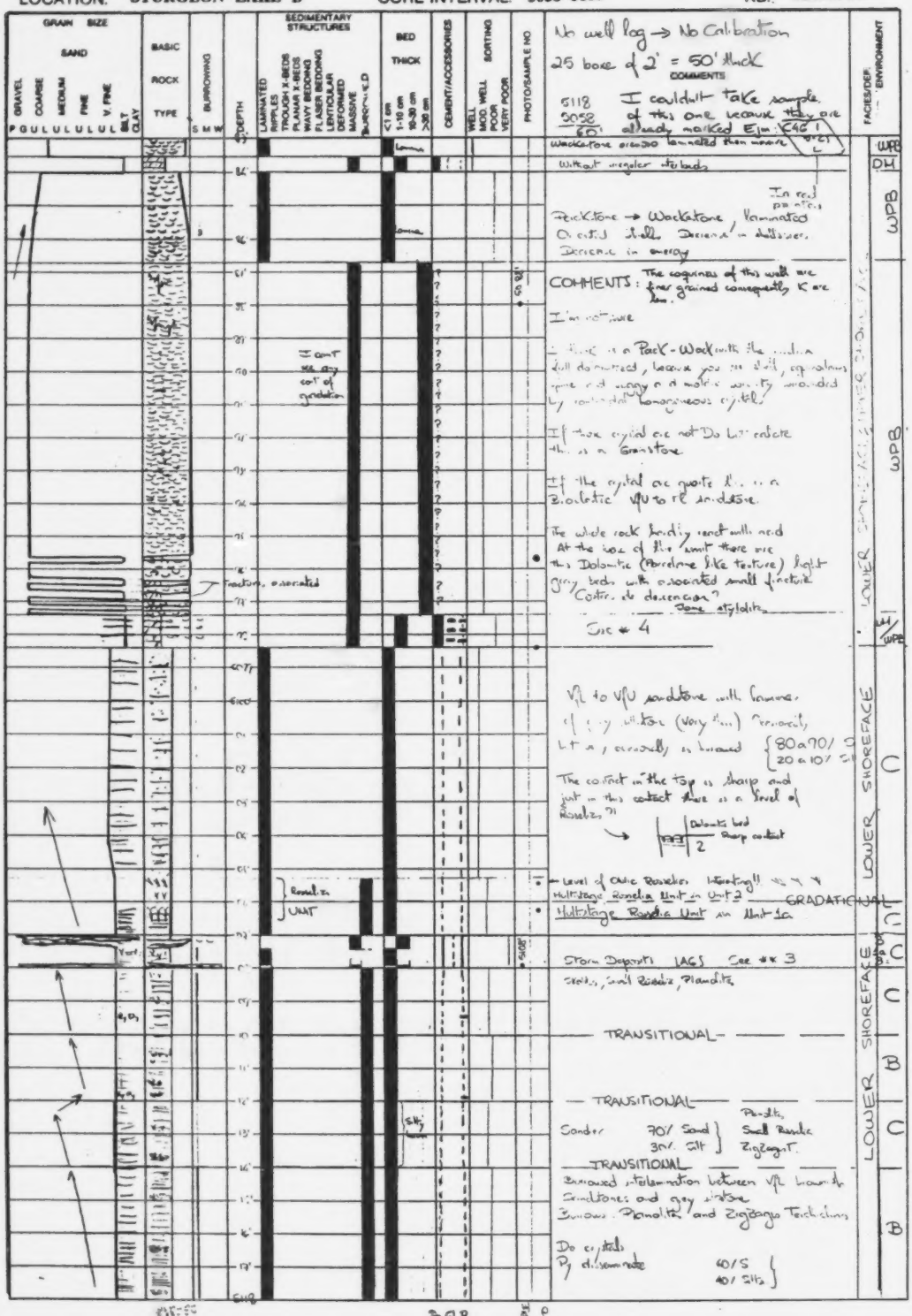
WELL NAME: 5-24-68-22W5 (2 OF 2) FORMATION: MONTNEY DATE: OCT. 14, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5094'-5147' KB: SLABBED



WELL NAME: 7-24-68-22W5 (1 OF 2) FORMATION: MONTNEY DATE OCT. 18, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: 5058'-5118' KB: SLABBED

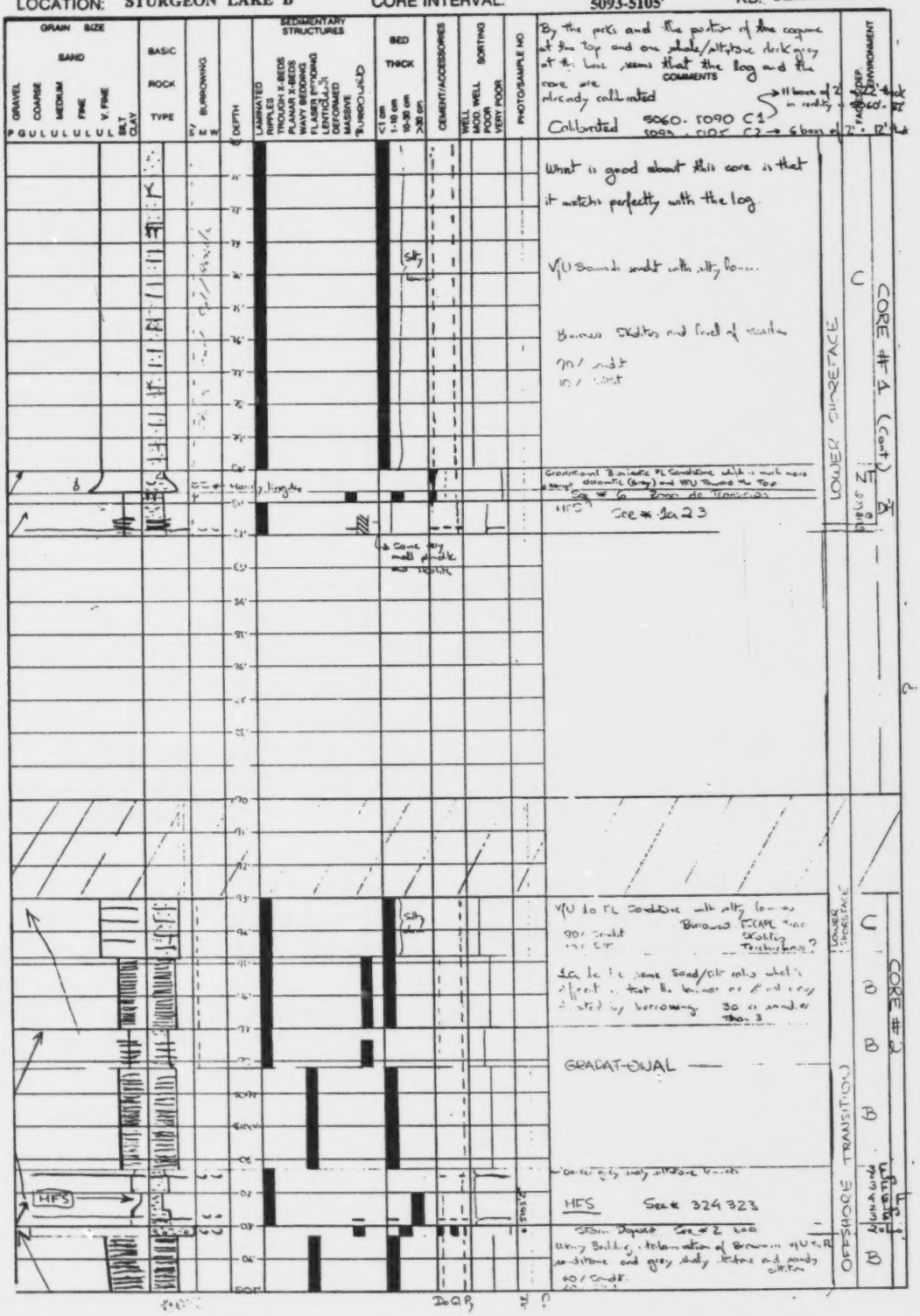

GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
CONVOLUTED
MASSIVE
BURROWED
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
WELL SORTING
MOD. WELL
POOR
VERY POOR
PHOTO/SAMPLE NO.
FACIES/DEP. ENVIRONMENT
No well log → No Calibration
25 bore of 2' = 50' thick
COMMENTS
5118
5058
60'
I couldn't take sample of this one because they are already marked E/m: E46 1 of 2
Wackestone or mud to lamellid then more
Without irregular interbeds
In real parts
Rock tone → Wackestone, laminated
Crinoid shells Decrease in diameter.
Decrease in energy
COMMENTS: The coquinas of this well are finer grained consequently K are low.
I'm not sure
It's a Rock - Wackestone the rock is dull dominated, because you see shell, coquinas some and many a matrix mainly wackestone by calcareous homogeneous crystals
If those crystal are not Do Lit: calcite this is a Grainstone
If the crystal are quartz this is a Dolomitic VFU to VF sandstone
The whole rock hardly react with acid At the top of the unit there are thin Dolomitic (Porcelain like texture) light grey beds with associated small fracture Contr. de decreacion?
Zone stylolite
See # 4
Fracture, associated
I can't see any sort of gradation
VF to VFU sandstone with laminae of grey siltstone (Very thin) Perversely Lit a, crossbedded is laminated {80 a 90% / 20 a 10%
The contact in the top is sharp and just in this contact there is a level of Rizodes ??
Dolomite bed
Ramp contact
Level of Oncic Rizodes Interbedded
Hultsteige Rizodes Unit in Unit 2
Hultsteige Rizodes Unit in Unit 1a
GRADATIONAL
Rizodes Unit
Storm Deposit LAG See # 3
shells, Small Rizodes, Planolites
TRANSITIONAL
TRANSITIONAL
Sandst 70% Sand 30% Silt
Planolites, Small Rizodes Zigzagging
TRANSITIONAL
Laminated interlamination between VF Limonite Sandstones and grey siltstone
Burrows: Planolites and Zigzagging Teichichnus
Do crystals Pg disseminate 40/S 40/Silt
LOWER SHOREFACE
WPB
DH
UPB

WELL NAME: 7-24-68-22W5 (2 OF 2) FORMATION: MONTNEY DATE: OCT. 18, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: 5058'-5118' KB: SLABBED

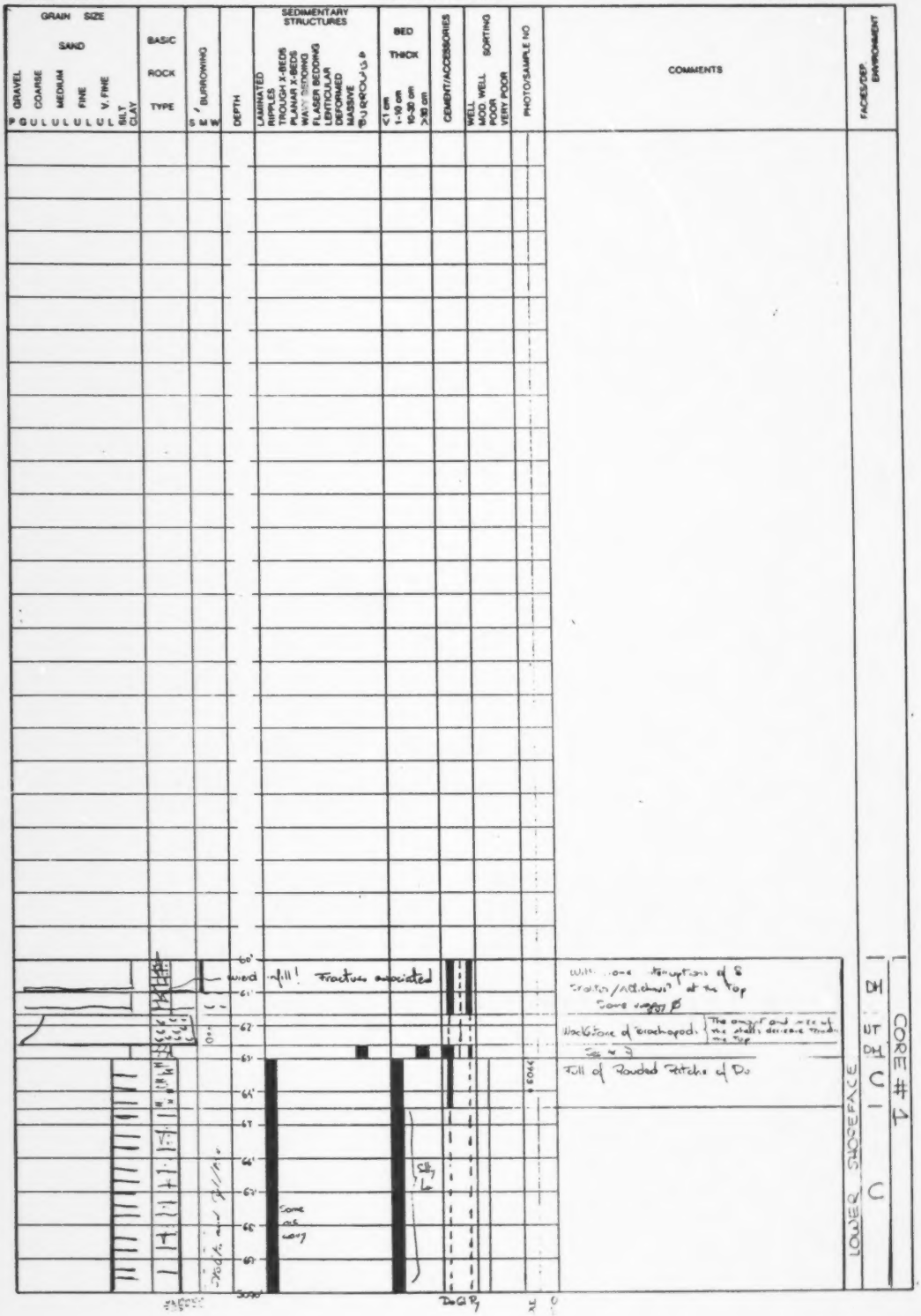
WELL NAME: 9-24-68-22W5 (1 OF 2) FORMATION MONTNEY DATE: OCT. 20, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5060'-5090' 5093-5105' KB: SLABBED



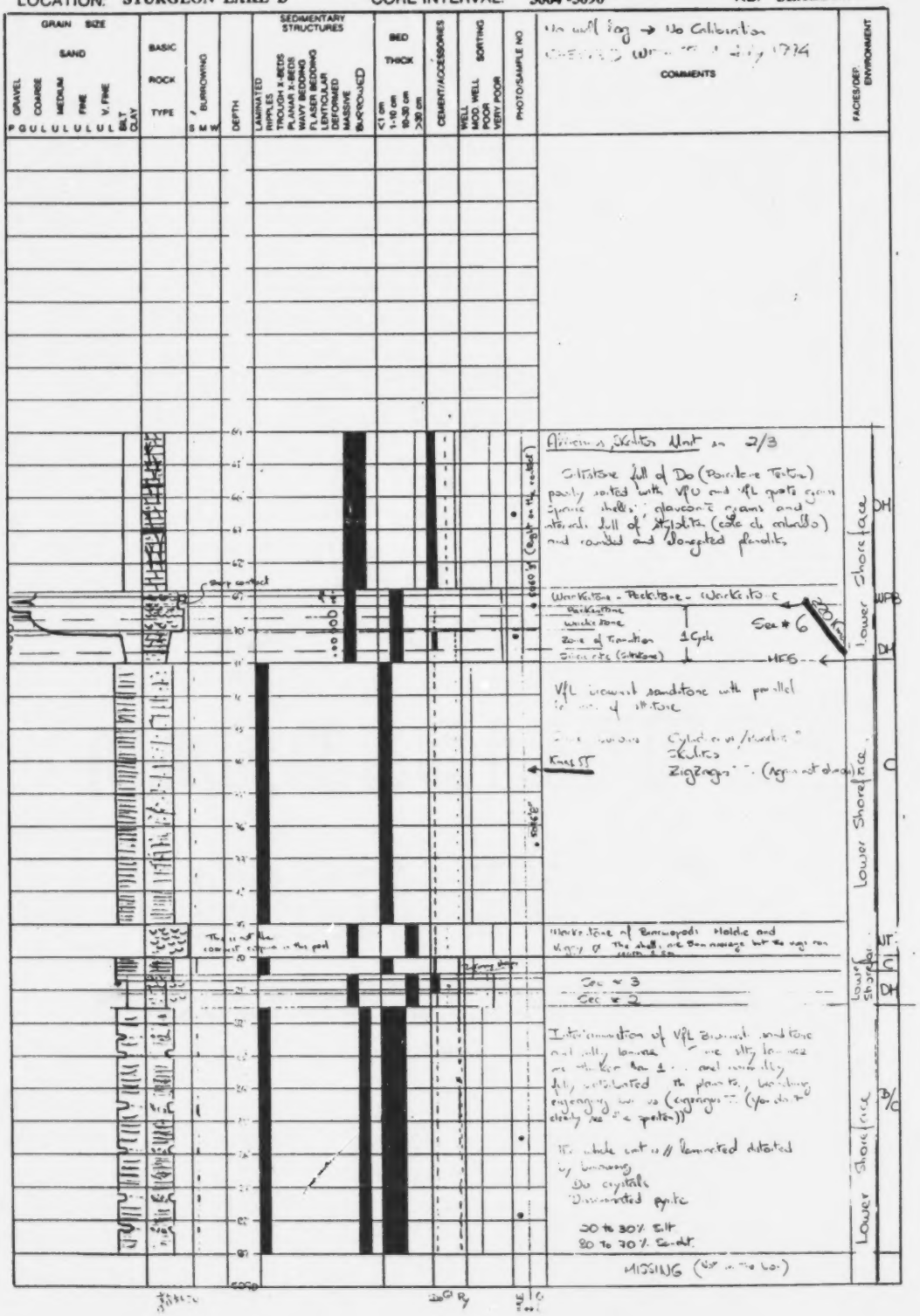
WELL NAME: 9-24-68-22W5 (2 OF 2) FORMATION: MONTNEY DATE: OCT. 20, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL BOXES: 5060'-5090' 5093-5105' KB: SLABBED



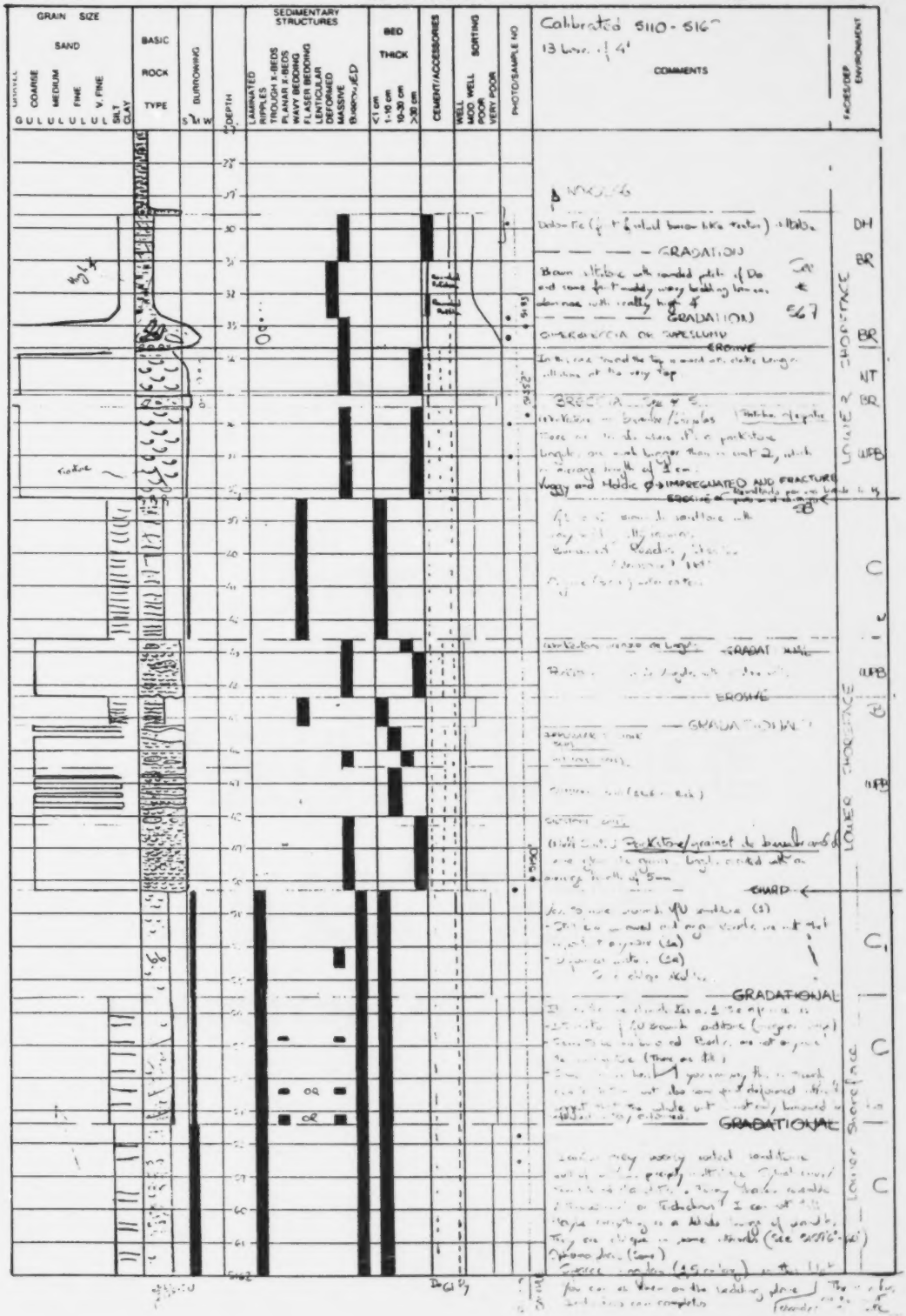
WELL NAME: 13-24-68-22W5 (1 OF 1) FORMATION: MONTNEY DATE: OCT. 21, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: 5064'-5090' KB: SLABBED



WELL NAME: 7-27-68-22W5 (1 OF 2) FORMATION: MONTNEY DATE: OCT. 21, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5114'-5164' KB: NOT SLABBED



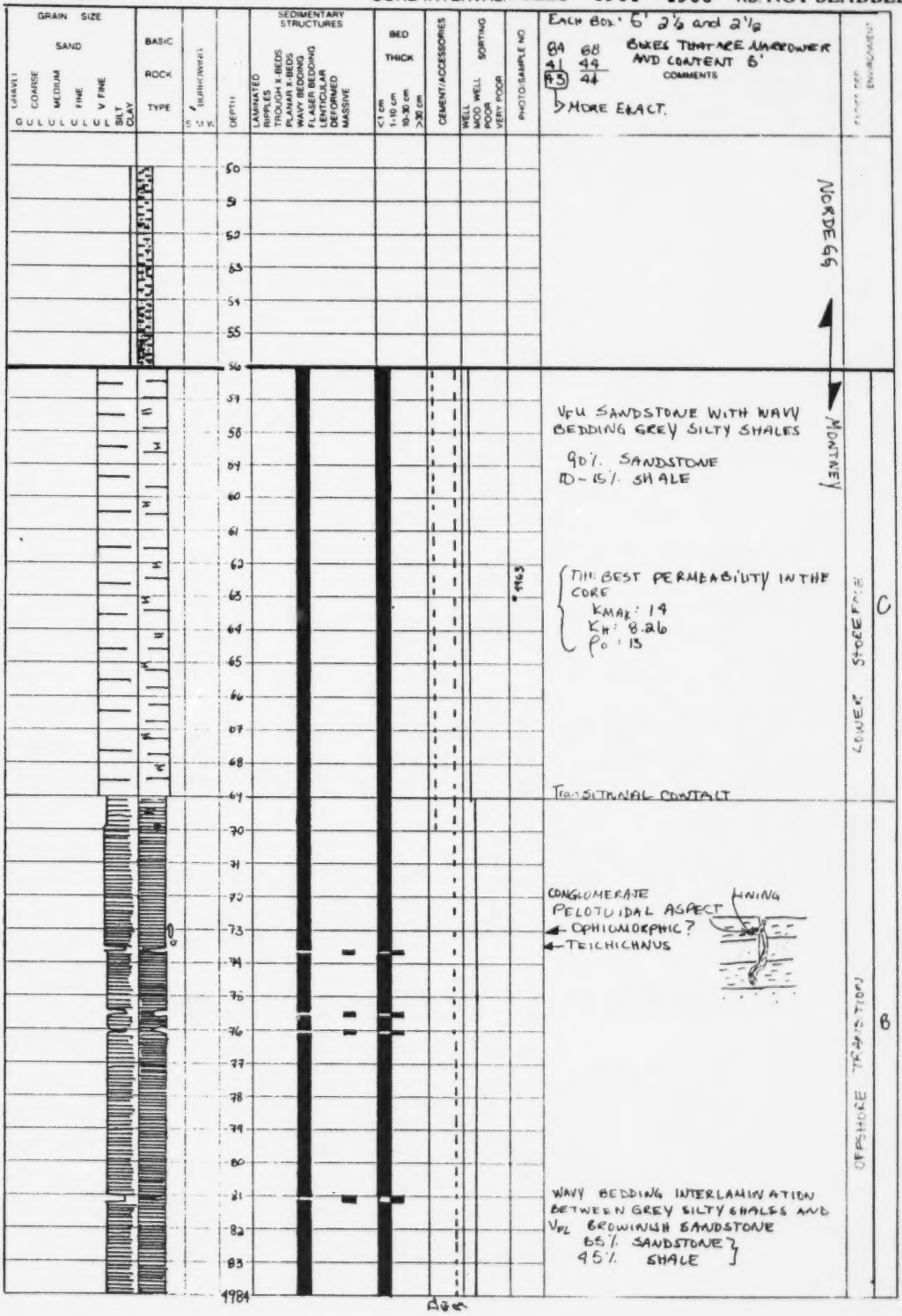
WELL NAME: 7-27-68-22W5 (2 OF 2) FORMATION: MONTNEY DATE: OCT. 21, 1993

LOCATION: STURGEON LAKE B CORE INTERVAL: BOXES: 5114'-5164' KB: NOT SLABBED

GRAIN SIZE: GRAVEL (GU)	SAND: COARSE (LU)	SAND: MEDIUM (LU)	SAND: FINE (LU)	SAND: V FINE (LU)	SILT (UL)	CLAY	BASIC ROCK TYPE	BURROWING: S	BURROWING: M	BURROWING: W	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED	RIPPLES	TROUGH X-BEDS	PLANAR X-BEDS	WAVY BEDDING	FLASER BEDDING	LENTICULAR	DEFORMED	MASSIVE	BED THICK: <1 cm	BED THICK: 1-10 cm	BED THICK: 10-30 cm	BED THICK: >30 cm	CEMENT/ACCESSORIES	SORTING: WELL	SORTING: MOD WELL	SORTING: POOR	SORTING: VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES/DEP ENVIRONMENT
																															Calibrated 5110 - 5162	

WELL NAME: 7-04-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JULY 22, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: CALIBRATED BOXES 4941'-4984' / 4944'-4988' KB: NOT SLABBED



WELL NAME: 7-04-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JULY 22, 1993

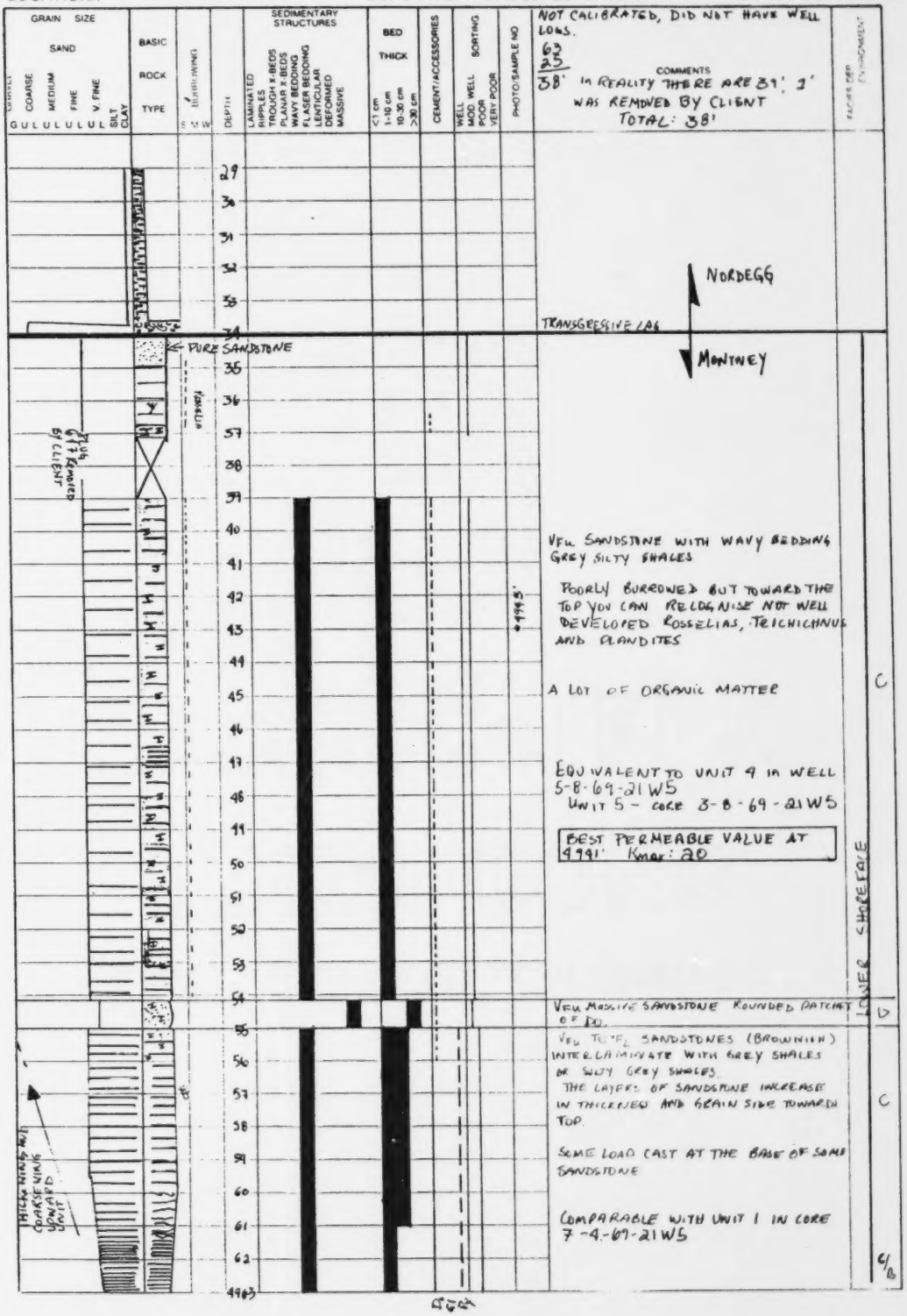
LOCATION: STURGEON LAKE A CALIBRATED 4941'-4984'

CORE INTERVAL BOXES 4944'-4988' KB NOT SLABBED

GRAIN SIZE: GRAVEL / COARSE / MEDIUM / FINE / V. FINE / SILT / CLAY	BASIC ROCK TYPE	S	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED / RIPPLES / TROUGH X-BEDS / PLANAR X-BEDS / WAVY BEDDING / FLASER BEDDING / LENTICULAR / DEFORMED / MASSIVE	BED THICK: <1 cm / 1-10 cm / 10-30 cm / >30 cm	CEMENT/ACCESSORIES	SORTING: WELL / MOD WELL / POOR / VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FAMES DEP
									43' of Core	
			38							
			39							
			40							
			41							
			42							
			43							
			44							
			45							
			46							
			47							
			48							
			49							
			4950'							

WELL NAME: 13-04-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE JULY 23, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4925-4963 KB NOT SLABBED


GRAIN SIZE
SAND
GRANULE COARSE MEDIUM FINE V. FINE SILT CLAY
BASIC ROCK TYPE
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED RIPPLES TROUGH X-BEDS PLANAR X-BEDS WAVY BEDDING FLASER BEDDING LENTICULAR DEFORMED MASSIVE
BED THICK <1 cm 1-10 cm 10-30 cm >30 cm
CEMENT/ACCESSORIES
WELL MOD POOR VERY POOR SORTING
PHOTO/SAMPLE NO
NOT CALIBRATED, DID NOT HAVE WELL LOGS.
63
25
38'
COMMENTS
IN REALITY THERE ARE 39', 1' WAS REMOVED BY CLIENT
TOTAL: 38'
FACIES DESCRIPTION
NORDEGG
TRANSGRESSIVE LAG
MONTNEY
PURE SANDSTONE
CORED BY CLIENT
VFL SANDSTONE WITH WAVY BEDDING GREY SILTY SHALES
POORLY BURROWED BUT TOWARD THE TOP YOU CAN RECOGNISE NOT WELL DEVELOPED ROSSELIAS, TEICHICHNUS AND PLANDITES
4995'
A LOT OF ORGANIC MATTER
EQUIVALENT TO UNIT 9 IN WELL 5-8-69-21W5
UNIT 5 - CORE 8-8-69-21W5
BEST PERMEABLE VALUE AT 4991' Kmax: 20
LOWER SHOREFACE
VFL MASSIVE SANDSTONE ROUNDED PATCHES OF DD.
VFL TO FL SANDSTONES (BROWNISH) INTERLAMINATE WITH GREY SHALES OR SILTY GREY SHALES.
THE LAYERS OF SANDSTONE INCREASE IN THICKNESS AND GRAIN SIDE TOWARD TOP.
SOME LOAD CAST AT THE BASE OF SOME SANDSTONE
COMPARABLE WITH UNIT 1 IN CORE 7-4-69-21W5
THICKENING AND COARSENING UPWARD UNIT
C
C
C/B

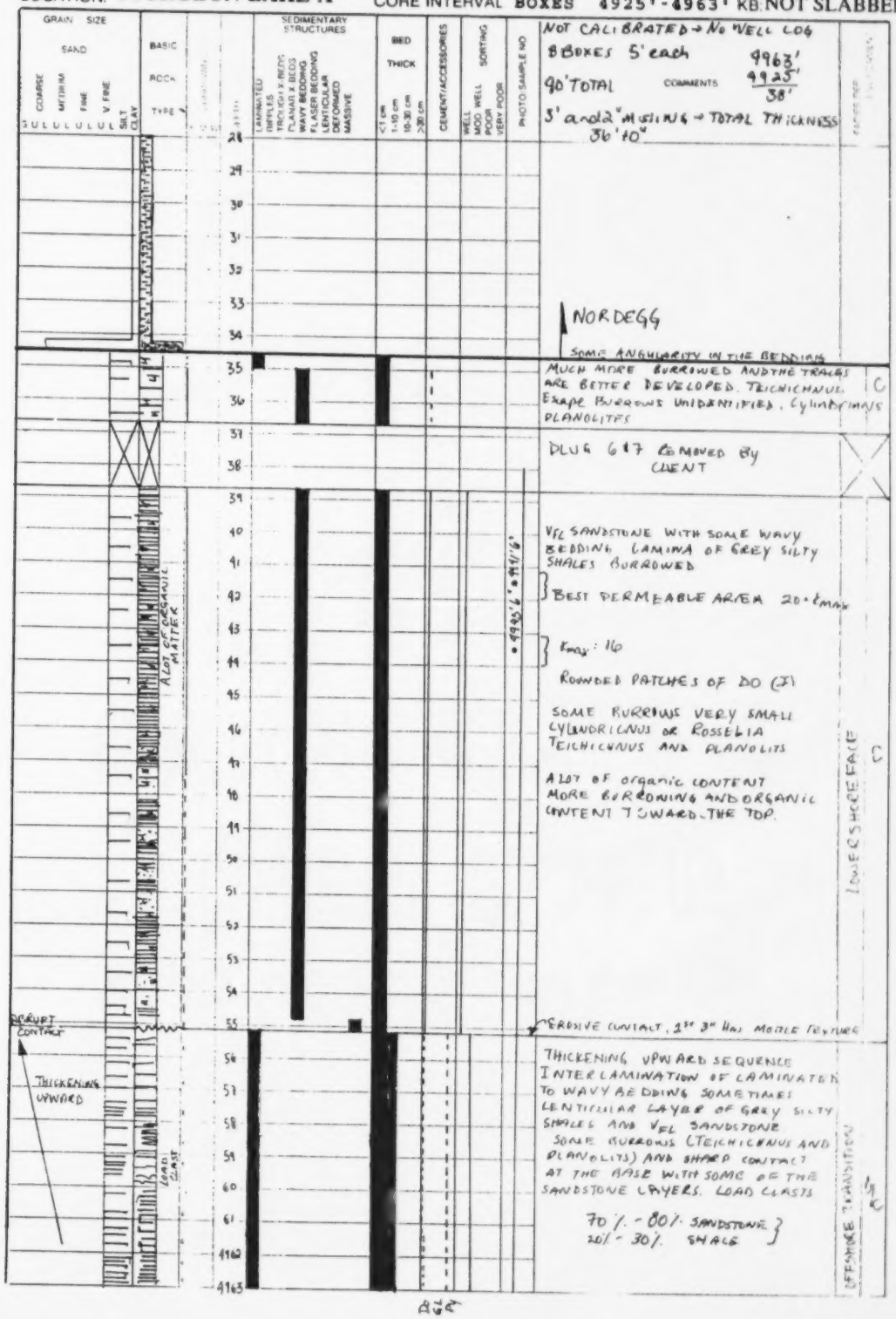
WELL NAME: 13-04-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE AUG. 23 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4925'-4963' KB NOT SLABBED

GRAIN SIZE: GRAVEL / SAND: COARSE, MEDIUM, FINE, V FINE / SILT / CLAY	BASIC ROCK TYPE	ENVIRONMENT	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED, RIPPLES, TROUGH X-BEDS, PLANAR X-BEDS, WAVY BEDDING, FLASER BEDDING, LENTICULAR, DEFORMED, MASSIVE	BED THICK: <1 cm, 1-10 cm, 10-30 cm, >30 cm	CEMENT/ACCESSORIES	SORTING: WELL, MOD. WELL, POOR, VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES, DEP ENVIRONMENT
			4924'						Nordegg	
			4928'							

WELL NAME: 13-04-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE AUG. 23, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL BOXES 4925'-4963' KB NOT SLABBED



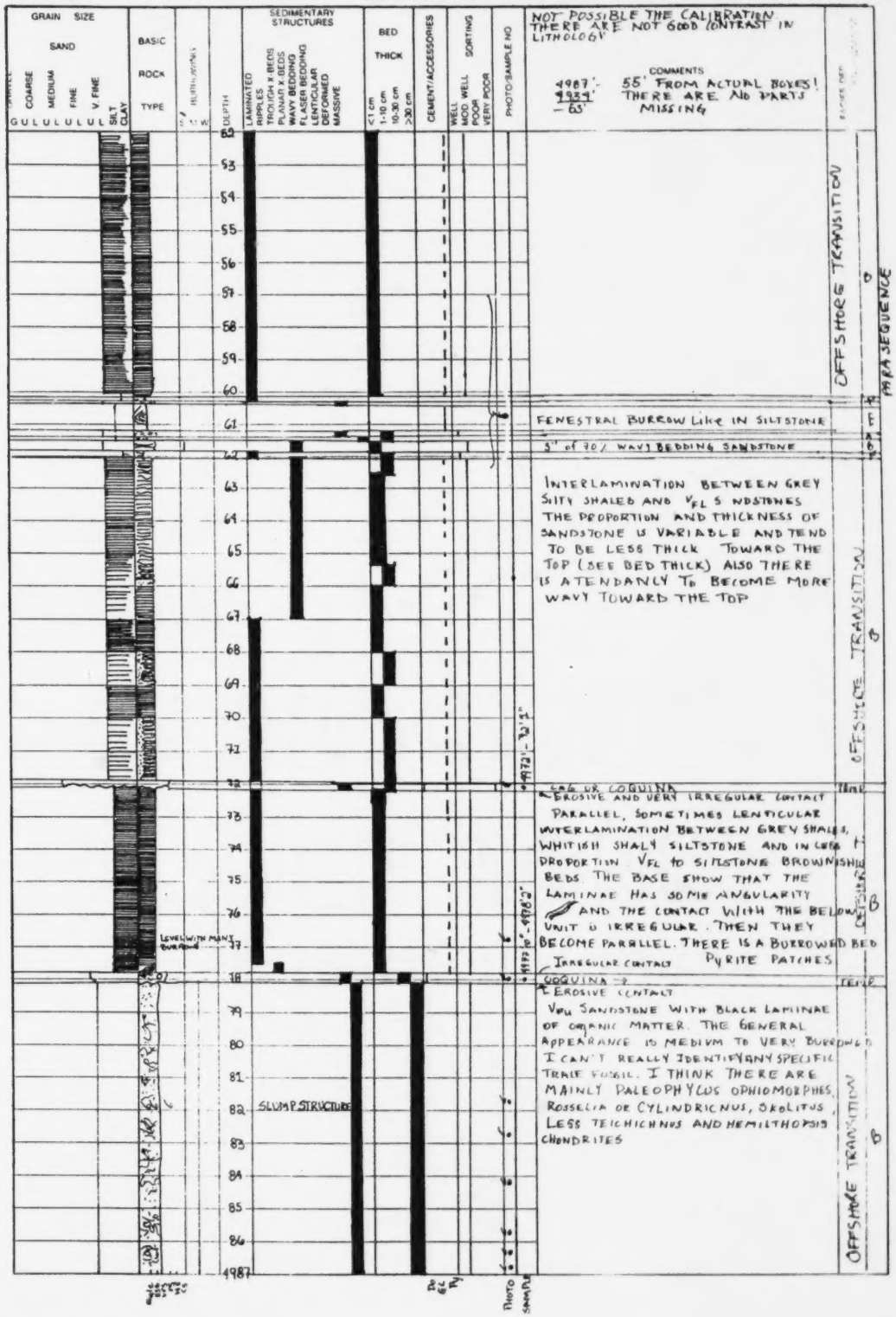
WELL NAME: 13-04-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE JULY 23, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4925'-4963' KB NOT SLABBED

GRAIN SIZE: SAND — COARSE / MEDIUM / FINE / V. FINE / SILT / CLAY	BASIC ROCK TYPE	PERFORATIONS	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED / RIPPLES / TROUGH X-BEDS / PLANAR X-BEDS / WAVY BEDDING / FLASER BEDDING / LENTICULAR / DEFORMED / MASSIVE	BED THICK: <1 cm / 1-10 cm / 10-30 cm / >30 cm	CEMENT/ACCESSORIES	SORTING: WELL / MOD WELL / POOR / VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES DEP ENVIRONMENT
									NOT CALIBRATED. DID NOT HAVE THE WELL LOGS.	
			24							
			25							
			26							
			27							
			28							
			4929							

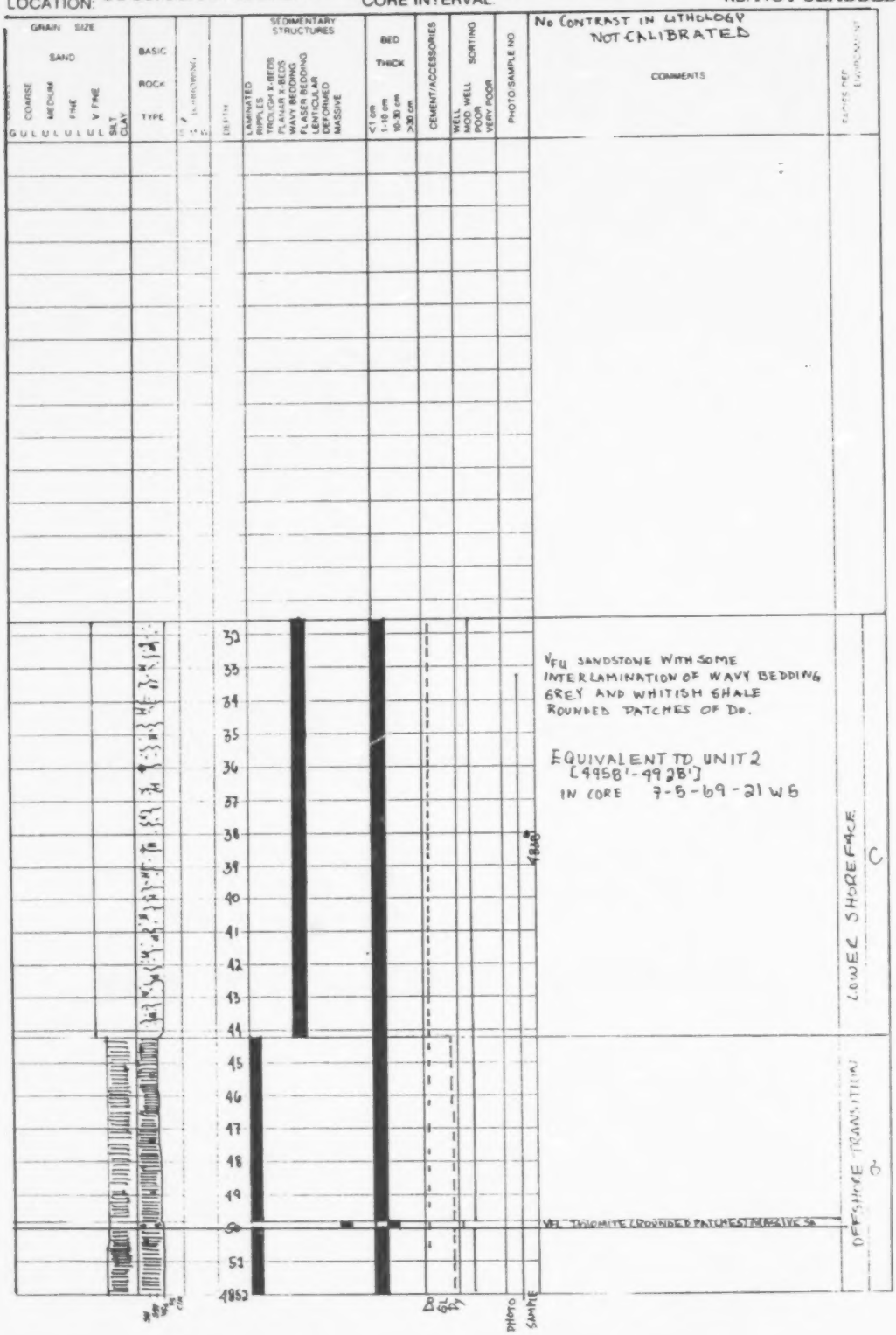
WELL NAME: 15-04-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JULY 23, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4934'-4987' KB NOT SLABBED


GRAIN SIZE
SAND
GRANULE
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD WELL
POOR
VERY POOR
PHOTO/SAMPLE NO
COMMENTS
NOT POSSIBLE THE CALIBRATION THERE ARE NOT GOOD CONTRAST IN LITHOLOGY
4987'-4934' = 53'
55' FROM ACTUAL BOXES! THERE ARE NO PARTS MISSING
OFFSHORE TRANSITION
MRA SEQUENCE
FENESTRAL BURROW LIKE IN SILTSTONE
5' of 70° WAVY BEDDING SANDSTONE
INTERLAMINATION BETWEEN GREY SILTY SHALES AND VFL SANDSTONES THE PROPORTION AND THICKNESS OF SANDSTONE IS VARIABLE AND TEND TO BE LESS THICK TOWARD THE TOP (SEE BED THICK) ALSO THERE IS A TENDANCY TO BECOME MORE WAVY TOWARD THE TOP
OFFSHORE TRANSITION
LAG OR COQUINA
EROSIVE AND VERY IRREGULAR CONTACT
PARALLEL, SOMETIMES LENTICULAR INTERLAMINATION BETWEEN GREY SHALES, WHITISH SHALY SILTSTONE AND IN LESS PROPORTION VFL to SILTSTONE BROWNISHIE BEDS. THE BASE SHOW THAT THE LAMINAE HAS SOME ANGULARITY AND THE CONTACT WITH THE BELOW UNIT IS IRREGULAR. THEN THEY BECOME PARALLEL. THERE IS A BURROWED BED
LEVEL WITH MANY BURROWS
IRREGULAR CONTACT
PYRITE PATCHES
COQUINA ?
EROSIVE CONTACT
VFL SANDSTONE WITH BLACK LAMINAE OF ORGANIC MATTER. THE GENERAL APPEARANCE IS MEDIUM TO VERY BURROWED I CAN'T REALLY IDENTIFY ANY SPECIFIC TRACE FOSSIL. I THINK THERE ARE MAINLY PALEOPHYCUS OPHIOMORPHES, ROSSELIA OR CYLINDRICNUS, SKOLITUS, LESS TEICHICHNUS AND HEMILITHOPSIS CHONDRITES
SLUMP STRUCTURE
OFFSHORE TRANSITION

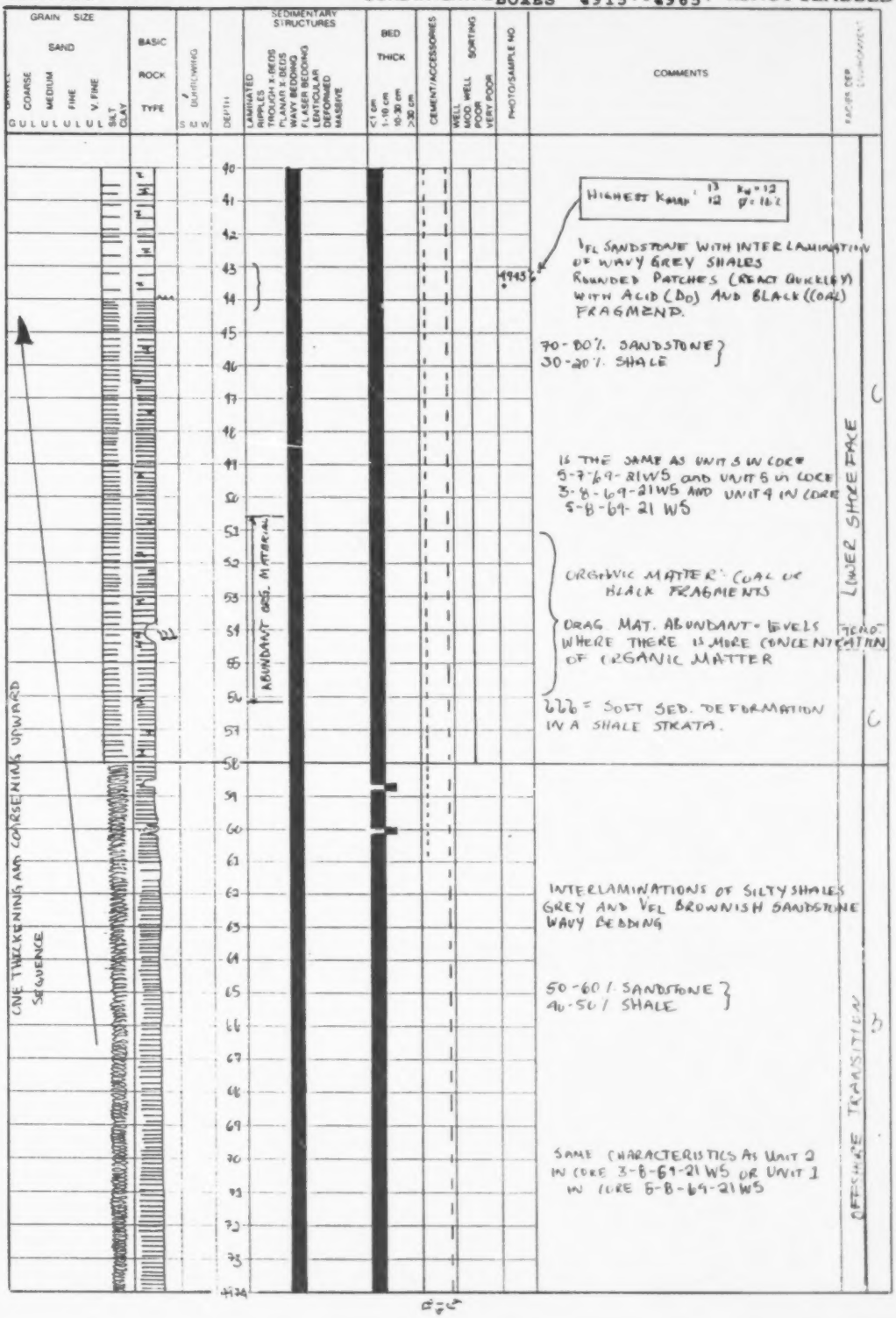
WELL NAME 15-4-69-21W5(2 OF 2) FORMATION: MONTNEY DATE JULY 23, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4934'-4987' KB: NOT SLABBED



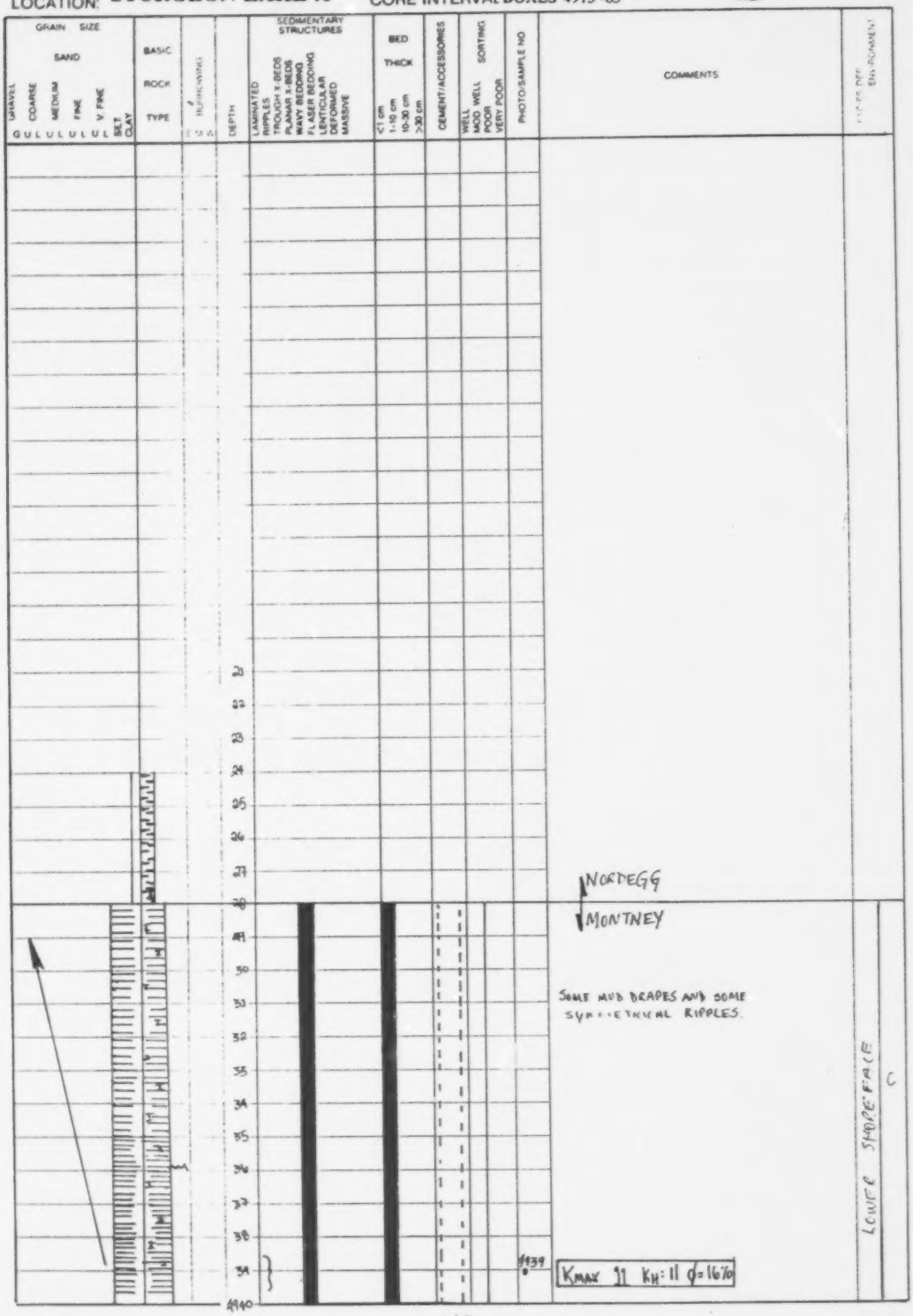
WELL NAME: 7-05-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE JUNE 15, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL CALIBRATED 4924'-4976' BOXES 4915'-4965' KB NOT SLABBED



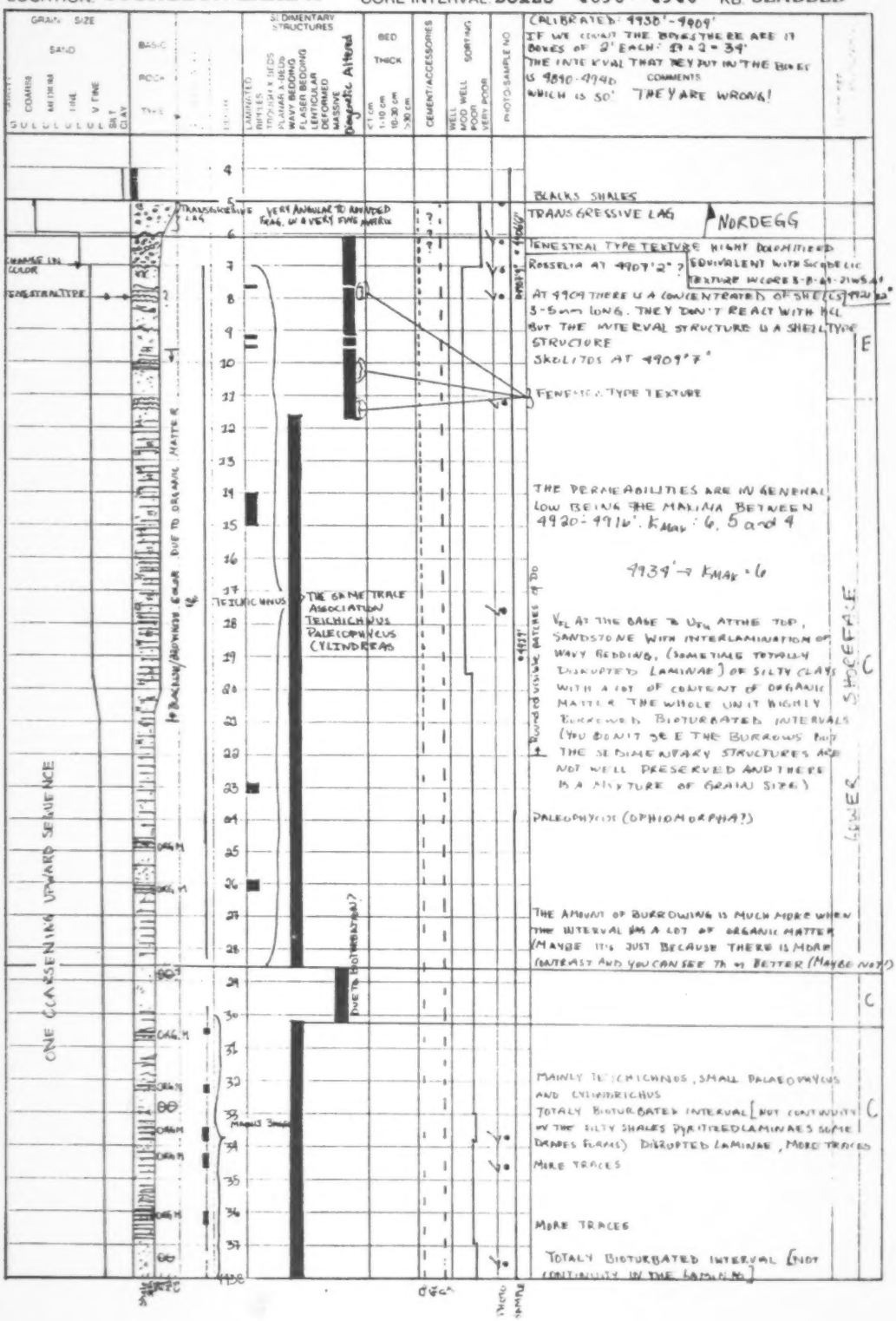
WELL NAME: 7-05-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE JUNE 15, 1993

LOCATION: STURGEON LAKE A CALIBRATED 4924'-4976' CORE INTERVAL BOXES 4915'-65' KB:



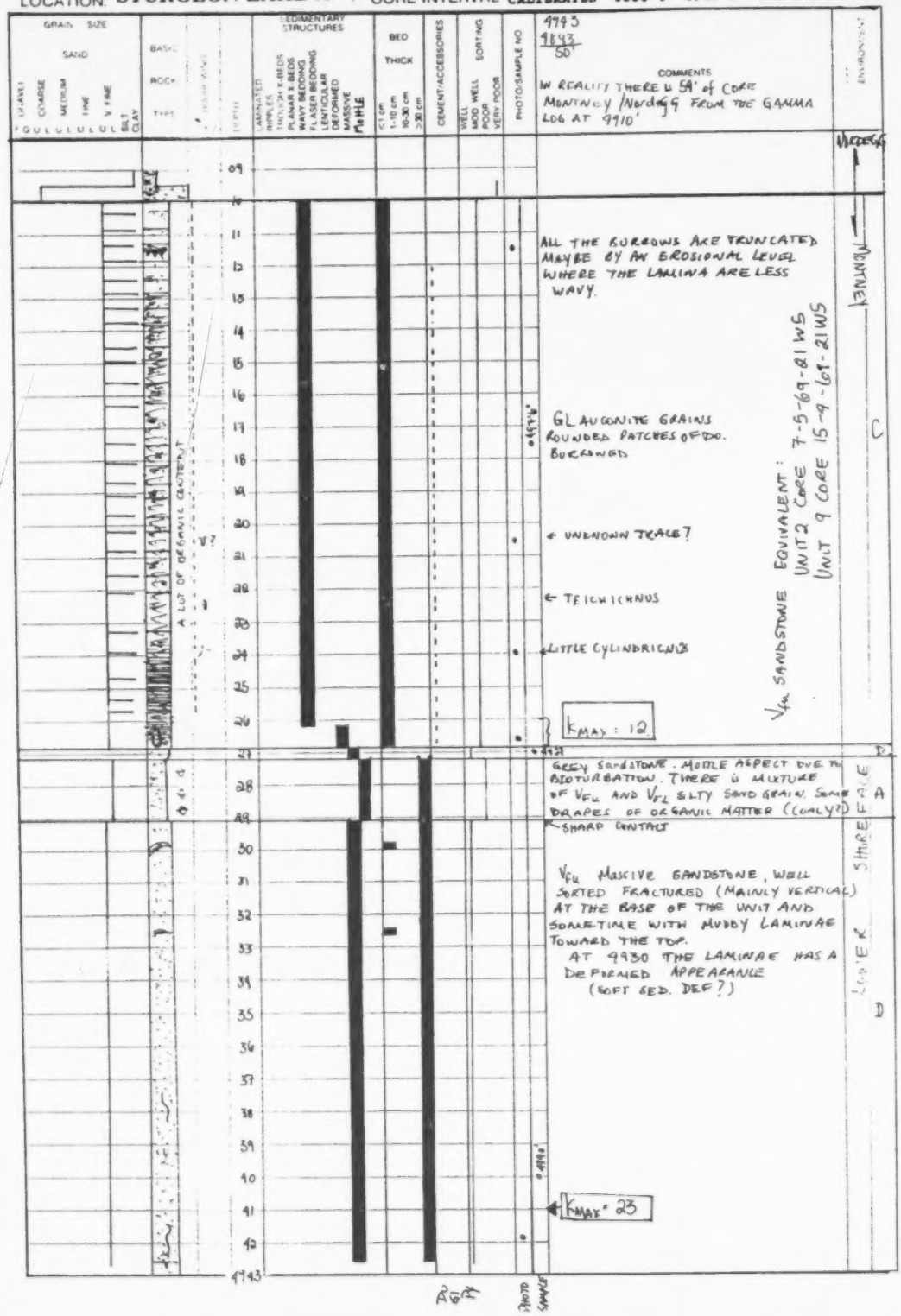
WELL NAME: 5-06-69-21W5 (1 OF 1) FORMATION: MONTNEY DATE JUNE 16, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4890'-4940' KB: SLABBED


CALIBRATED: 4930'-4909'
IF WE COUNT THE BOXES THERE ARE 11 BOXES OF 3' EACH: 11 x 3 = 33'
THE INTERVAL THAT THEY PUT IN THE BOXES IS 4890-4940 COMMENTS
WHICH IS 50' THEY ARE WRONG!
BLACKS SHALES
TRANSGRESSIVE LAG
NORDEGG
TENESTRAL TYPE TEXTURE RIGHT DOLOMITIZED
ROSSELLA AT 4907'2" ?
EQUIVALENT WITH SICADELIC
AT 4909 THERE U A CONCENTRATED OF SHELLS
3-5mm LONG. THEY DON'T REACT WITH HCL
BUT THE INTERVAL STRUCTURE U A SHELL TYPE STRUCTURE
SKOLITOS AT 4909'7"
FENESTRAL TYPE TEXTURE
THE PERMEABILITIES ARE IN GENERAL LOW BEING THE MAXIMA BETWEEN 4920-4916'. KMAX: 6, 5 and 4
4939' → KMAX = 6
THE SAME TRACE ASSOCIATION TEICHICHNUS PALEOPHYCUS CYLINDREAS
PALEOPHYCUS (OPHIOMORPHA?)
THE AMOUNT OF BURROWING IS MUCH MORE WHEN THE INTERVAL IS A LOT OF ORGANIC MATTER (MAYBE IT'S JUST BECAUSE THERE IS MORE CONTRAST AND YOU CAN SEE IT BETTER (MAYBE NOT)
MAINLY TEICHICHNUS, SMALL PALEOPHYCUS AND CYLINDRICHUS
TOTALLY BIOTURBATED INTERVAL [NOT CONTINUITY OF THE SILTY SHALES PYRITIZED LAMINAE SOME DENSES FLASER) DISRUPTED LAMINAE, MORE TRACES
MORE TRACES
MORE TRACES
TOTALLY BIOTURBATED INTERVAL [NOT CONTINUITY IN THE LAMINAE]
ONE COARSENING UPWARD SEQUENCE
LOWER SHOREFACE

WELL NAME: 9-06-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JULY 28, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4893'-4943' CALIBRATED 4888'6"-4942'6" NOT SLABBED



WELL NAME: 9-06-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JULY 28, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: CALIBRATED 4888'6"-4942'6" BOXES 4893' - 4943' KB NOT SLABBED

GRAIN SIZE: GRAVEL	SAND: COARSE	SAND: MEDIUM	SAND: FINE	SAND: V FINE	SILT	CLAY	BASIC ROCK TYPE	BURROWING: F	BURROWING: S	BURROWING: A	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED	RIPPLES	TROUGH X-BEDS	PLANAR X-BEDS	WAVY BEDDING	FLASER BEDDING	LENTICULAR	CONTORTED	MASSIVE	BED THICK: <1 cm	1-10 cm	10-30 cm	>30 cm	CEMENT/ACCESSORIES	SORTING: WELL	MOD WELL	POOR	VERY POOR	PHOTO/SAMPLE NO.	COMMENTS
																														14 Boxes Mont/Nord Contact 9910' 59 of core

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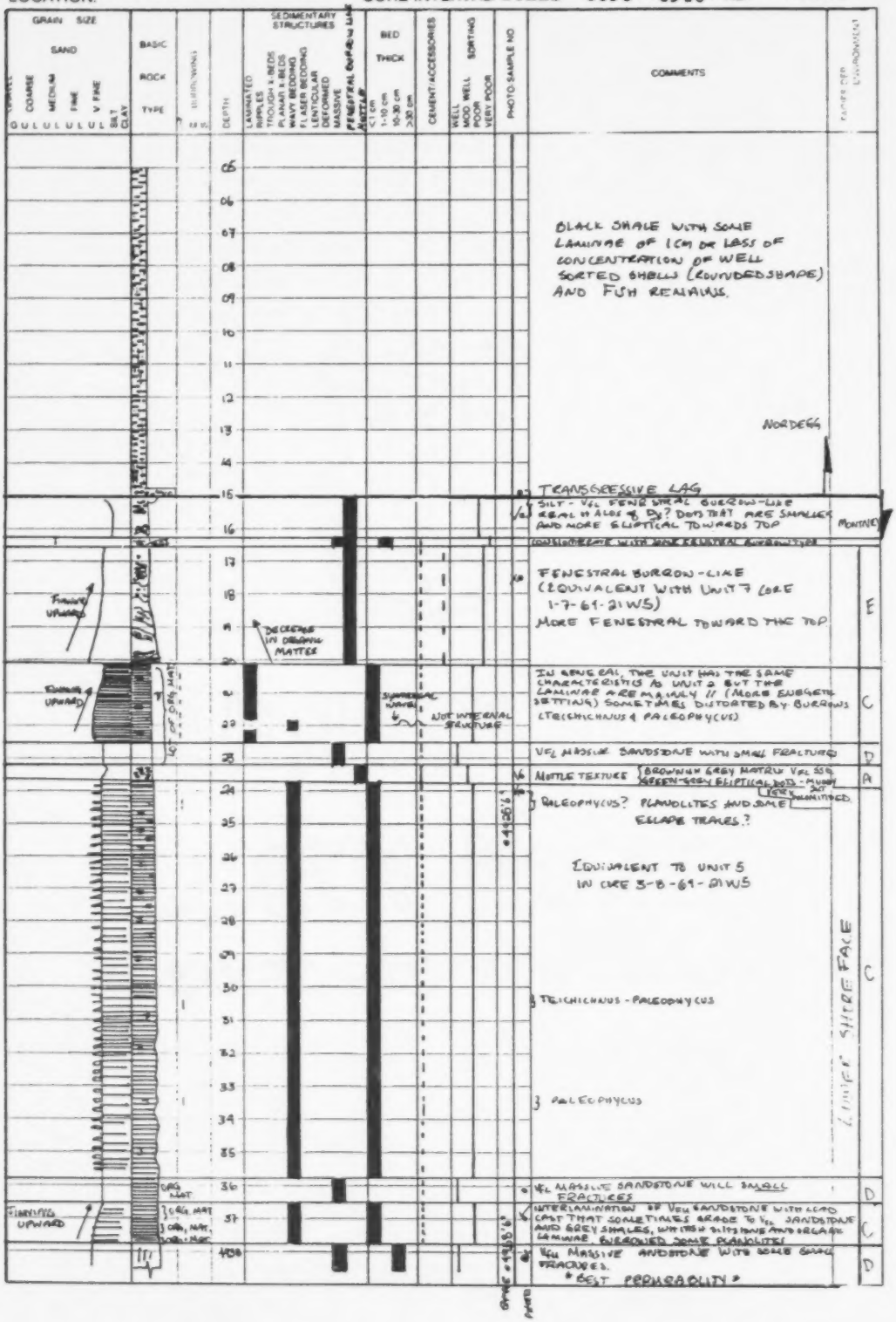
4894
9900
01
02
03
04
05
06
07
09
4909

WELL NAME: 11-06-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JUNE 28, 1993

LOCATION: STURGEON LAKE A CALIBRATED 4938'6"-4888'6" CORE INTERVAL: BOXES 4896'-4946' KB: SLABBED



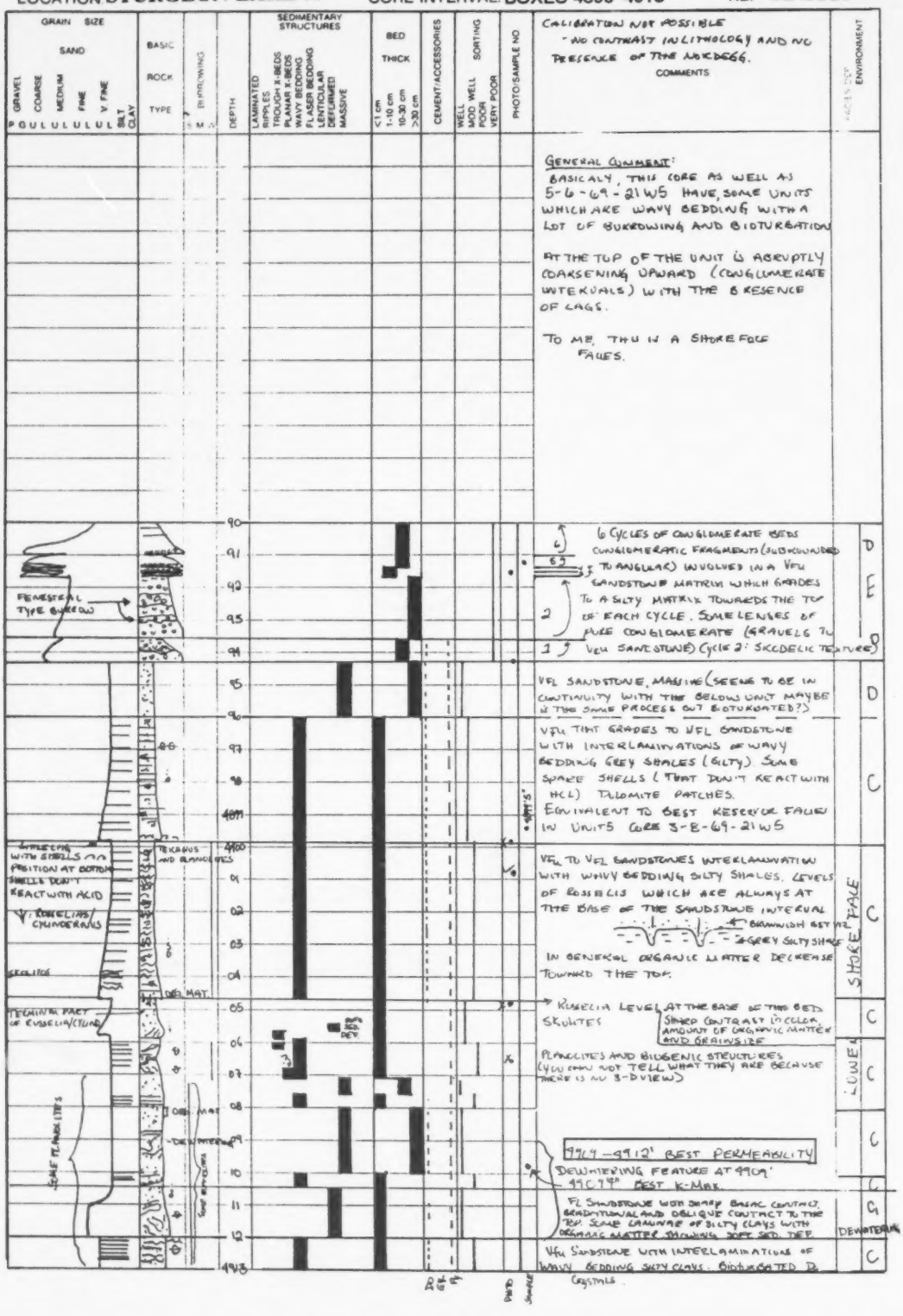
WELL NAME: 11-06-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JUNE 29, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL CALIBRATED 4938'6"-4888'6" BOXES 4896'-4946' KB: SLABBED

GRAIN SIZE: GRAVEL (P)	GRAIN SIZE: SAND: COARSE (G)	GRAIN SIZE: SAND: MEDIUM (U)	GRAIN SIZE: SAND: FINE (L)	GRAIN SIZE: SAND: V FINE (U)	GRAIN SIZE: SILT (L)	GRAIN SIZE: CLAY	BASIC ROCK TYPE	RUBBLY/VUG (S M W)	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED	RIPPLES	TROUGH X-BEDS	PLANAR X-BEDS	WAVY BEDDING	FLASER BEDDING	LENTICULAR	DEFORMED	MASSIVE	BED THICK: <1 cm	1-10 cm	10-30 cm	>30 cm	CEMENT/ACCESSORIES	SORTING: WELL	MOD WELL	POOR	VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES DESCRIPTION ENVIRONMENT
									87																					
									88																					
									89																					
									90																				FRAGMENT OF COAL NET!	
									91																					
									92																					
									93																					
									94																					
									95																					
									96																					
									97																					
									98																				SILTSTONE	
									99																					
									490a																				SILTSTONE	
									01																					
									02																					
									03																					
									04																					
									05																					

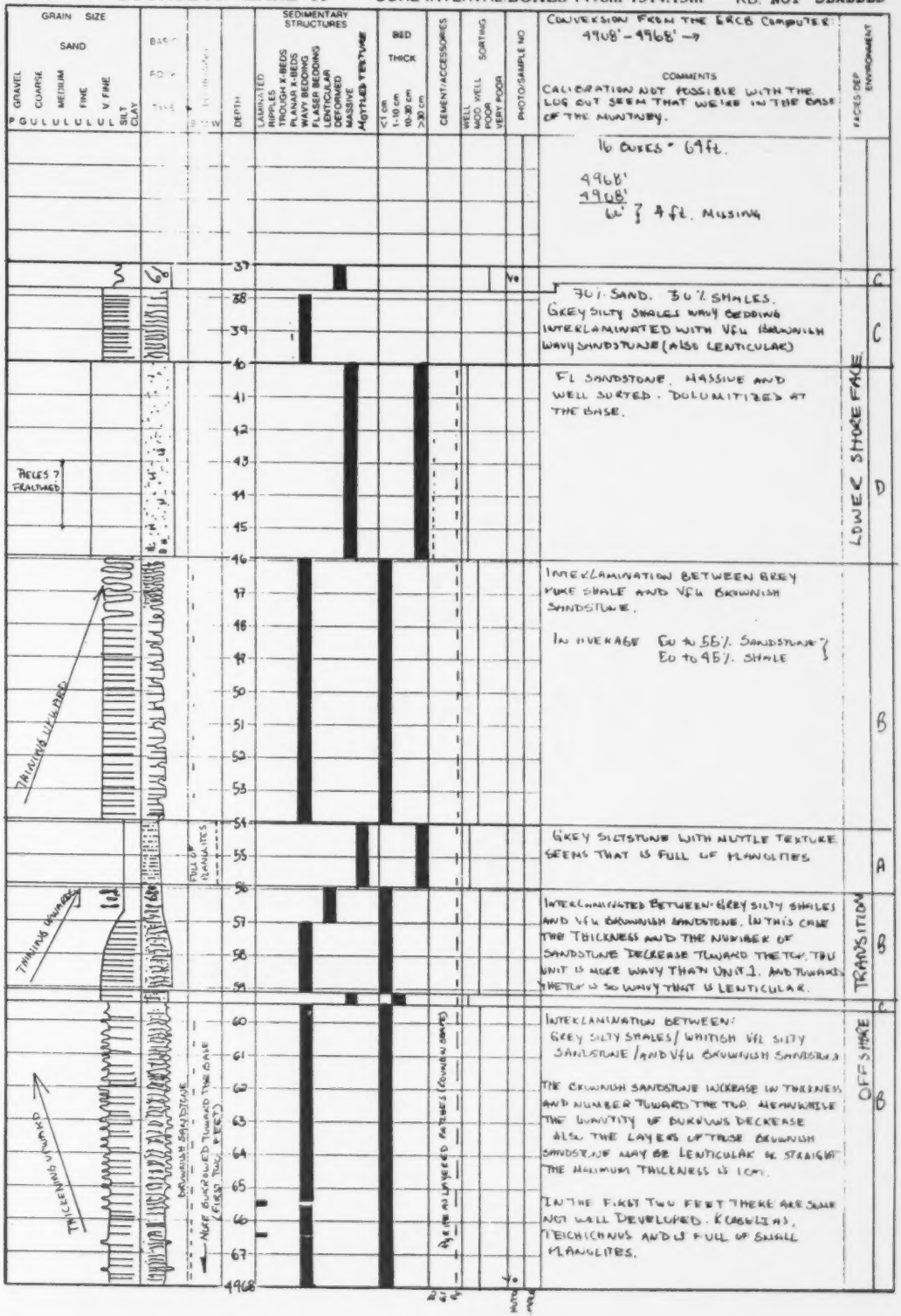
WELL NAME: 13-06-69-21W5 (1 OF 1) FORMATION: MONTNEY DATE JUNE 18, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4890'-4913' KB: SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD WELL
POOR
VERY POOR
PHOTO/SAMPLE NO
CALIBRATION NOT POSSIBLE - NO CONTRAST IN LITHOLOGY AND NO PRESENCE OF THE MARKER BED.
COMMENTS
ENVIRONMENT
GENERAL COMMENT:
BASICALY, THIS CORE AS WELL AS 5-6-69-21W5 HAVE SOME UNITS WHICH ARE WAVY BEDDING WITH A LOT OF BURROWING AND BIOTURBATION
AT THE TOP OF THE UNIT IS ABRUPTLY COARSENING UPWARD (CONGLOMERATE INTERVALS) WITH THE PRESENCE OF LAGS.
TO ME, THIS IN A SHOREFACE FACIES.
FENESTRAL TYPE BURROW
6 CYCLES OF CONGLOMERATE BEDS CONGLOMERATIC FRAGMENTS (SUBROUNDED TO ANGULAR) INVOLVES IN A VFL SANDSTONE MATRIX WHICH GRADES TO A SILTY MATRIX TOWARDS THE TOP OF EACH CYCLE. SOME LENSES OF PURE CONGLOMERATE (GRAVELS TO VFL SANDSTONE) CYCLE 2: SKOLOCLIC TEXTURE
VFL SANDSTONE, MASSIVE (SEEMS TO BE IN CONTINUITY WITH THE BELOW UNIT MAYBE IN THE SAME PROCESS BUT BIOTURBATED?)
VFL TINT GRADES TO VFL SANDSTONE WITH INTERLAMINATIONS OF WAVY BEDDING GREY SHALES (SILTY). SOME SPARSE SHELLS (THAT DON'T REACT WITH HCL) DOLOMITE PATCHES.
EQUIVALENT TO BEST RESERVOIR FACIES IN UNITS CORE 3-8-69-21W5
4100'S
TEICHICHNUS AND BIOTURBATED
WITH SHELLS IN A POSITION AT BOTTOM
SHELLS DON'T REACT WITH ACID
ROSELLIS/ CYLINDRICHNUS
SCOLITOS
DEB MAT
TERMINATION OF ROSELLIS/CYLINDRICHNUS
DEB MAT
SOME PLANOLITES
VFL TO VFL SANDSTONES INTERLAMINATION WITH WAVY BEDDING SILTY SHALES. LEVELS OF ROSELLIS WHICH ARE ALWAYS AT THE BASE OF THE SANDSTONE INTERVAL
BROWNISH SILTY SHALE
GREY SILTY SHALE
IN GENERAL ORGANIC MATTER DECREASE TOWARD THE TOP.
SHOREFACE
ROSELLIS LEVEL AT THE BASE OF THIS BED SKOLITES
SHARP CONTRAST IN COLOR, AMOUNT OF ORGANIC MATTER AND GRAINSIZE
PLANOLITES AND BIOGENIC STRUCTURES (YOU CANNOT TELL WHAT THEY ARE BECAUSE THERE IS NO 3-D VIEW)
LOWER
9969-9912' BEST PERMEABILITY
DEWATERING FEATURE AT 9969'
9979' BEST K-MAX
VFL SANDSTONE WITH SHARP BASAL CONTACT, GRADATIONAL AND OBLIQUE CONTACT TO THE TOP. SOME LAMINAE OF SILTY CLAYS WITH ORGANIC MATTER SHOWING SOFT SED. DEF.
DEWATERING
VFL SANDSTONE WITH INTERLAMINATIONS OF WAVY BEDDING SILTY CLAYS. BIOTURBATED PYRITE CRYSTALS
ABUNDANCE
SHAPE

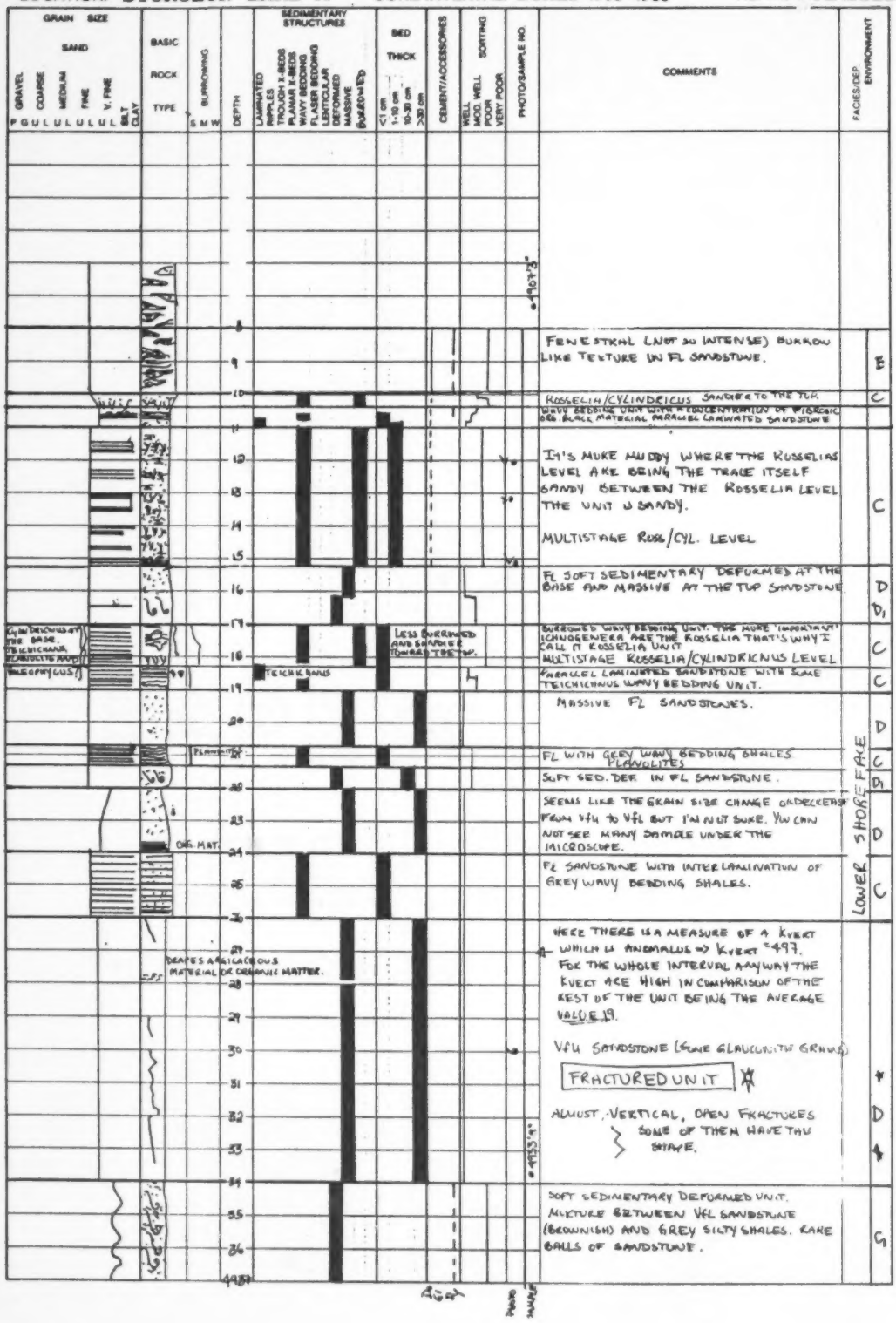
WELL NAME: 14-06-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE JULY 20, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 1496m-1514.15m KB: NOT SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V FINE
SILT
CLAY
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
MOTTLES TEXTURE
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD. WELL
POOR
VERY POOR
PHOTO/SAMPLE NO
DEPTH
CONVERSION FROM THE ERCB COMPUTER
4908' - 4968' → 9
COMMENTS
CALIBRATION NOT POSSIBLE WITH THE LOG CUT SEEM THAT WE'RE IN THE BASE OF THE MONTNEY.
FACIES DEP ENVIRONMENT
16 BOXES = 69ft.
4968'
4968'
W.? 4ft. MISSING
30% SAND. 30% SHALES.
GREY SILTY SHALES WAVY BEDDING INTERLAMINATED WITH VFL BROWNISH WAVY SANDSTONE (ALSO LENTICULAR)
FL SANDSTONE. MASSIVE AND WELL SORTED. DOLOMITIZED AT THE BASE.
LOWER SHORE FACE
FACES ? FRACTURED
INTERLAMINATION BETWEEN GREY DARK SHALE AND VFL BROWNISH SANDSTONE.
IN AVERAGE Eq to 55% SANDSTONE ?
Eq to 45% SHALE ?
THINNING UPWARD
GREY SILTSTONE WITH MOTTLE TEXTURE SEEMS THAT IS FULL OF FLANGLITES
FULL OF FLANGLITES
INTERLAMINATED BETWEEN: GREY SILTY SHALES AND VFL BROWNISH SANDSTONE. IN THIS CASE THE THICKNESS AND THE NUMBER OF SANDSTONE DECREASE TOWARD THE TOP. THE UNIT IS MORE WAVY THAN UNIT 1. AND TOWARD THE TOP IS SO WAVY THAT IS LENTICULAR.
TRANSITION
THINNING UPWARD
INTERLAMINATION BETWEEN:
GREY SILTY SHALES / WHITISH VFL SILTY SANDSTONE / AND VFL BROWNISH SANDSTONE
THE BROWNISH SANDSTONE INCREASE IN THICKNESS AND NUMBER TOWARD THE TOP. MEANWHILE THE QUANTITY OF DARKNESS DECREASE ALSO THE LAYERS OF THESE BROWNISH SANDSTONE MAY BE LENTICULAR OR STRAIGHT THE MAXIMUM THICKNESS IS 1cm.
IN THE FIRST TWO FEET THERE ARE SOME NOT WELL DEVELOPED. PLANOLITES, TEICHICHNUS AND IS FULL OF SMALL FLANGLITES.
OFFSHORE
THICKENING UPWARD
BROWNISH SANDSTONE
NOT BURROWED TOWARD THE BASE (FIRST TWO FEET)
4968

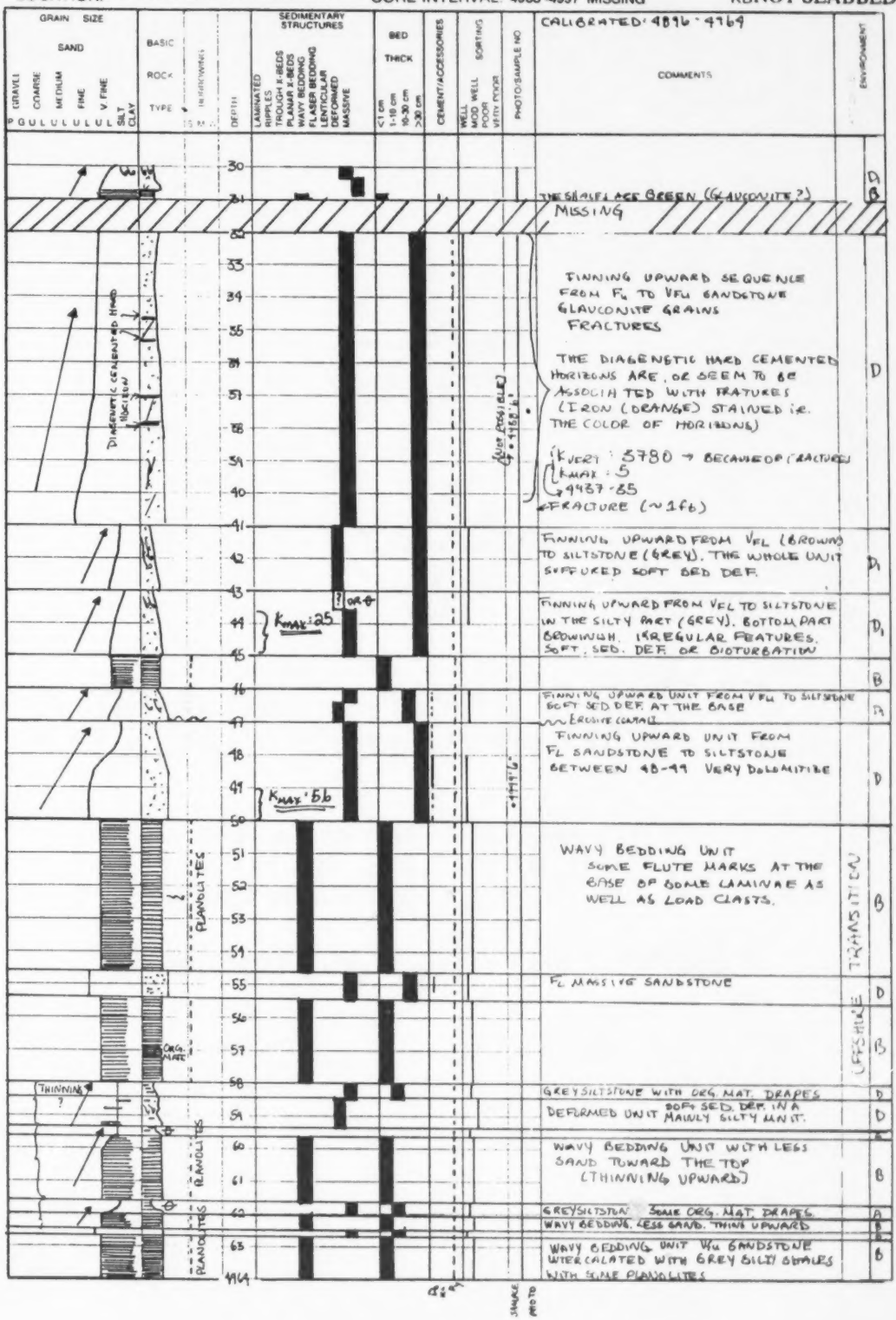
WELL NAME 14-06-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JULY 20, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4908'-4968' KB: NOT SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BURROWED
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD WELL
POOR
VERY POOR
PHOTO/SAMPLE NO.
COMMENTS
FACIES/DEP. ENVIRONMENT
FENESTRAL (NOT SO INTENSE) BURROW LIKE TEXTURE IN FL SANDSTONE.
ROSSELIA/CYLINDRICUS SANDSTONE TO THE TOP.
WAVY BEDDING UNIT WITH A CONCENTRATION OF BIOTURBIC ORG. BLACK MATERIAL PARALLEL LAMINATED SANDSTONE
IT'S MORE MUDDY WHERE THE ROSSELIA LEVEL ARE BEING THE TRACE ITSELF SANDY BETWEEN THE ROSSELIA LEVEL THE UNIT IS SANDY.
MULTISTAGE ROSS/CYL. LEVEL
FL SOFT SEDIMENTARY DEFORMED AT THE BASE AND MASSIVE AT THE TOP SANDSTONE.
BIOTURBATED WAVY BEDDING UNIT. THE MORE IMPORTANT ICHNOGENERA ARE THE ROSSELIA THAT'S WHY I CALL IT ROSSELIA UNIT
MULTISTAGE ROSSELIA/CYLINDRICNUS LEVEL
PARALLEL LAMINATED SANDSTONE WITH SOME TEICHICHNUS WAVY BEDDING UNIT.
MASSIVE FL SANDSTONES.
FL WITH GREY WAVY BEDDING SHALES
PLANOLITES
SOFT SED. DEF. IN FL SANDSTONE.
SEEMS LIKE THE GRAIN SIZE CHANGE GRADECREASE FROM Vfu TO Vfl BUT I'M NOT SURE. YOU CAN NOT SEE MANY SAMPLE UNDER THE MICROSCOPE.
FL SANDSTONE WITH INTERLAMINATION OF GREY WAVY BEDDING SHALES.
LOWER SHOREFACE
HERE THERE IS A MEASURE OF A KVERT WHICH IS ANOMALUS => KVERT =497. FOR THE WHOLE INTERVAL ANYWAY THE KVERT ARE HIGH IN COMPARISON OF THE REST OF THE UNIT BEING THE AVERAGE VALUE 19.
Vfu SANDSTONE (SOME GLAUCONITIC GRAINS)
FRACTURED UNIT
ALMOST VERTICAL, OPEN FRACTURES
SOME OF THEM HAVE THIS SHAPE.
SOFT SEDIMENTARY DEFORMED UNIT.
MIXTURE BETWEEN Vfl SANDSTONE (BROWNISH) AND GREY SILTY SHALES. FAKE BALLS OF SANDSTONE.
DEPOSITIONAL ENVIRONMENT

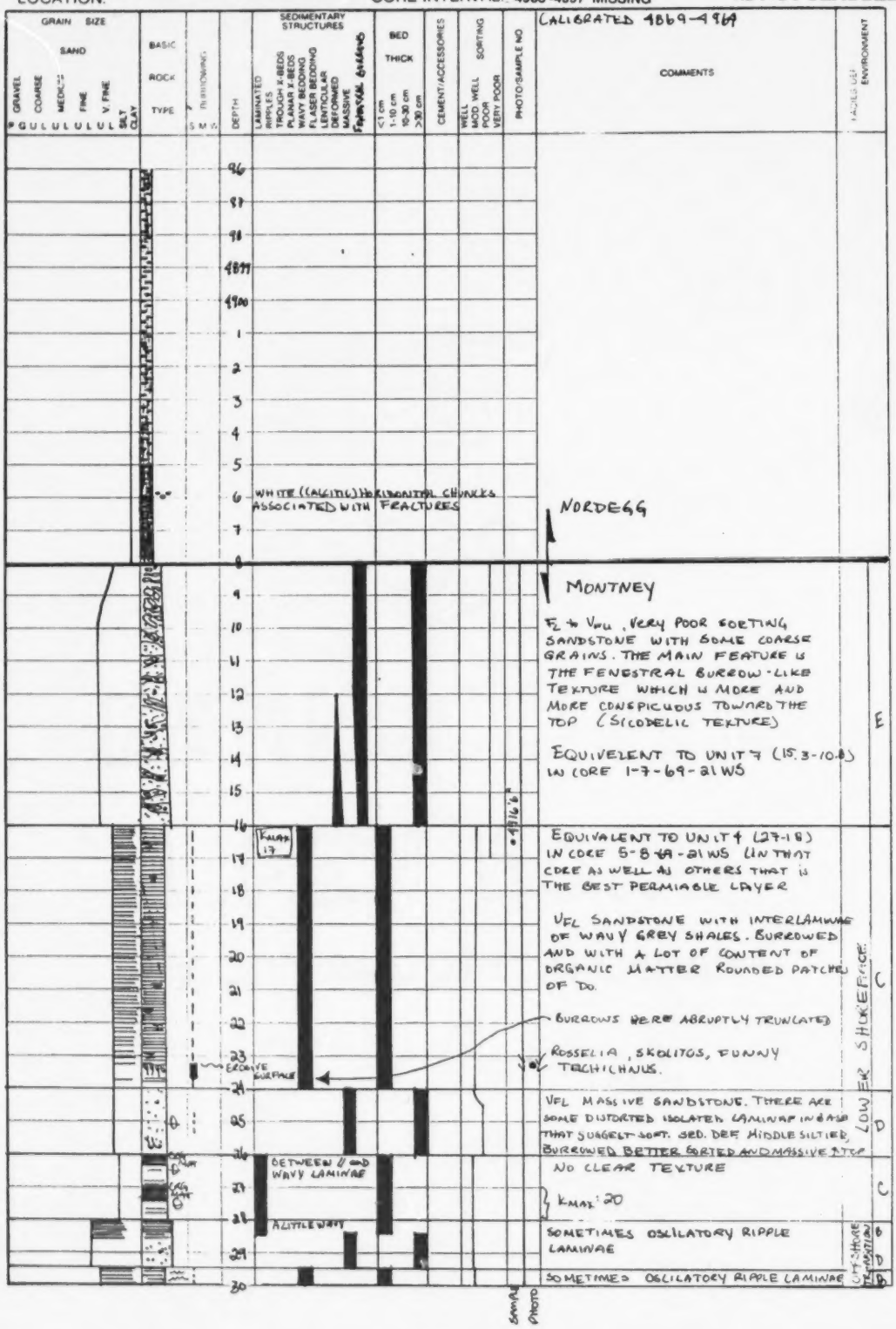
WELL NAME: 15-06-69-21W5 (1 OF 2) FORMATION: MONTNEY BOXES 4963'-4897' DATE JULY 14, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4963'-4997' MISSING KB NOT SLABBED



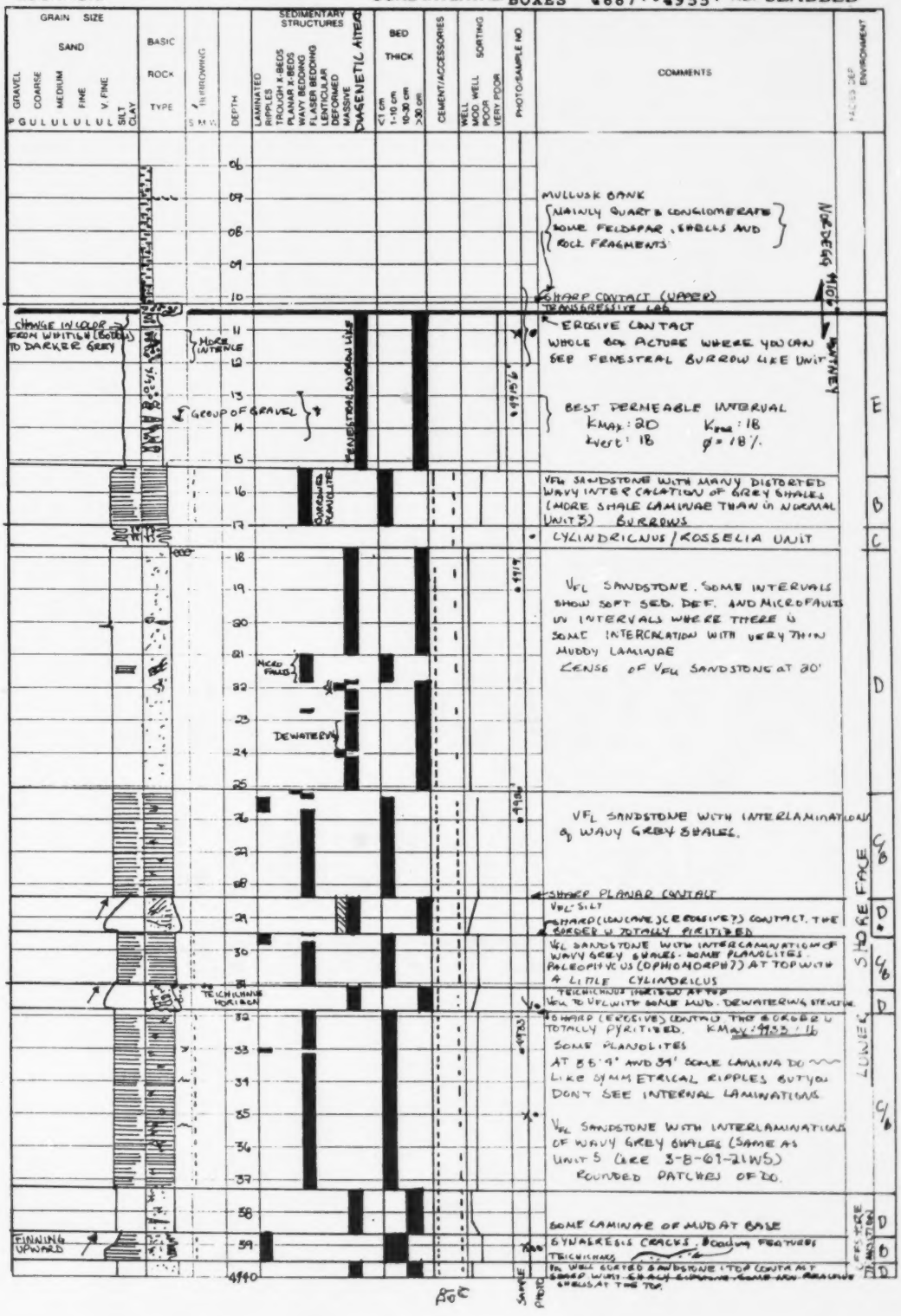
WELL NAME: 15-06-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE JULY 14, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4963'-4897' 4963'-4997' MISSING KB NOT SLABBED



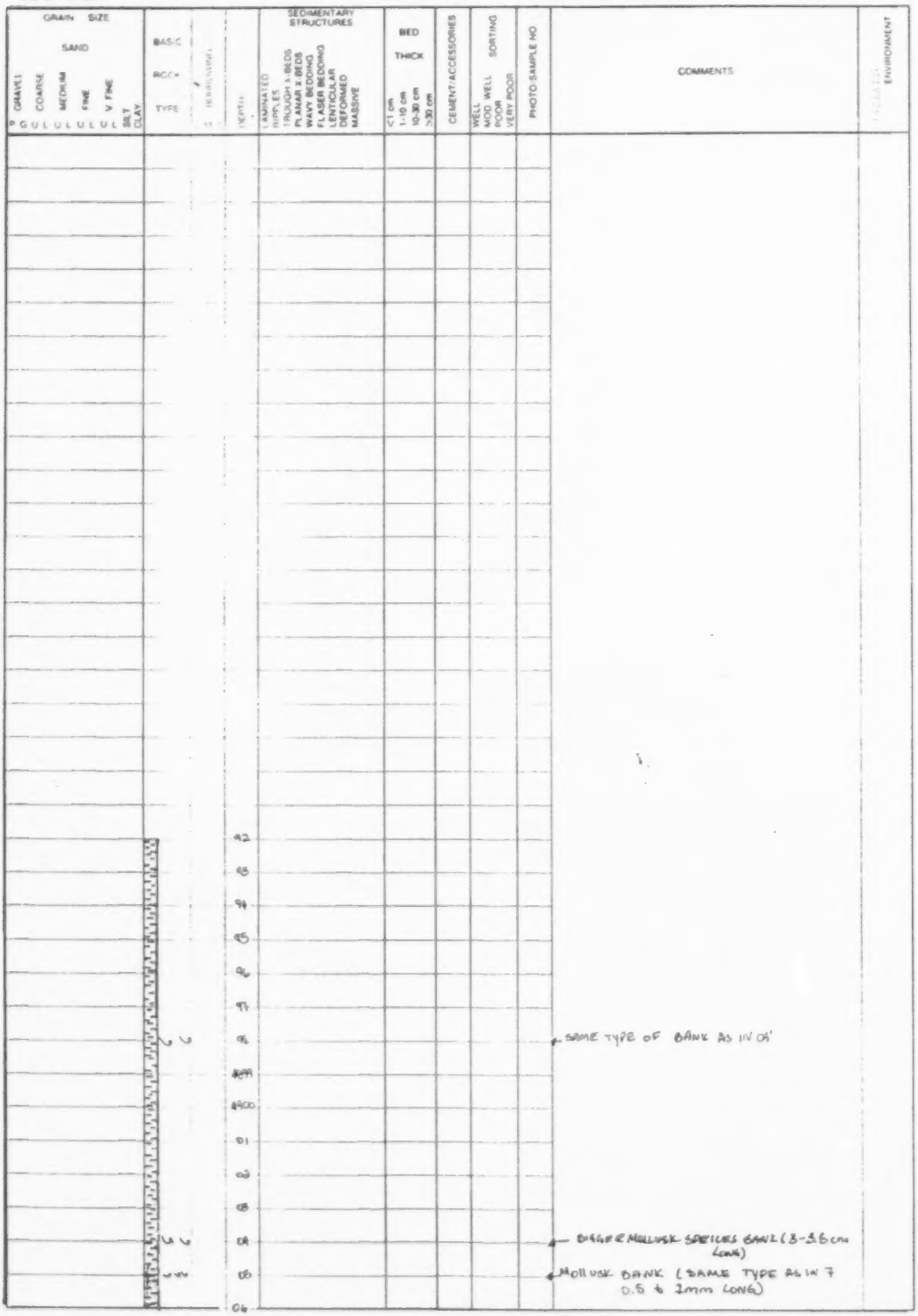
WELL NAME: 1-07-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE JUNE 24, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: CALIBRATED 4892'-4940' BOXES 4887'-4955' KB: SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BIOTURBATION
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
DIAGENETIC AITEDS
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD WELL
POOR
VERY POOR
PHOTO/SAMPLE NO
COMMENTS
ENVIRONMENT
MULLUSK BANK
MAINLY QUART & CONGLOMERATE SOME FELDSPAR, PEBBLES AND ROCK FRAGMENTS
SHARP CONTACT (UPPER)
TRANSGRESSIVE LAG
NOREEN MBR
CHANGE IN COLOR FROM WHITISH (BIOTURB) TO DARKER GREY
MORE INTENSE
GROUP OF GRAVEL
SANDSTONE BURROW LINED
ERODSIVE CONTACT
WHOLE BOX PICTURE WHERE YOU CAN SEE FENESTRAL BURROW LIKE UNIT
MONTNEY
BEST PERMEABLE INTERVAL
KMAX: 20 KHOR: 18
KVERT: 18 φ = 18%
VFL SANDSTONE WITH MANY DISTORTED WAVY INTERCALATION OF GREY SHALES (MORE SHALE LAMINAE THAN IN NORMAL UNIT 3) BURROWS
CYLINDRICNUS / ROSSELIA UNIT
VFL SANDSTONE. SOME INTERVALS SHOW SOFT SED. DEF. AND MICROFAULTS IN INTERVALS WHERE THERE IS SOME INTERCALATION WITH VERY THIN MUDDY LAMINAE
LENSE OF VFL SANDSTONE AT 30'
MICRO FAULT
DEWATERING
VFL SANDSTONE WITH INTERLAMINATIONS OF WAVY GREY SHALES.
SHARP PLANAR CONTACT
VFL SILT
SHARP (LOW ANGLE) (EROSIVE?) CONTACT. THE BORDER IS TOTALLY PYRITIZED
VFL SANDSTONE WITH INTERLAMINATIONS OF WAVY GREY SHALES. SOME PLANOLITES PALEOPHYCUS (OPHIOMORPH?) AT TOP WITH A LITTLE CYLINDRICUS
TEICHICHNUS HORIZON
TEICHICHNUS INCREASED ABUNDANCE
VFL TO VFL WITH SOME MUD. DEWATERING STRUCTURE
SHARP (EROSIVE) CONTACT THE BORDER IS TOTALLY PYRITIZED. KMAX: 1933 : 16
SOME PLANOLITES
AT 33'9" AND 34' SOME LAMINA DO LIKE SYMMETRICAL RIPPLES BUT YOU DONT SEE INTERNAL LAMINATIONS
VFL SANDSTONE WITH INTERLAMINATIONS OF WAVY GREY SHALES (SAME AS UNIT 5 LIKE 3-8-61-21W5) ROUNDED PATCHES OF ZO.
SOME LAMINAE OF MUD AT BASE
SYNAERESIS CRACKS. Scouring FEATURES
TEICHICHNUS
FINING UPWARD
FINE WELL SORTED SANDSTONE ITOP CONTACT SHARP WITH SHALE CLASTS. SOME NON-RESISTIVE CLASTS AT THE TOP
LOWER SHOREFACE
OFFSHORE TRANSITION
4940
SAMPLE PHOTO

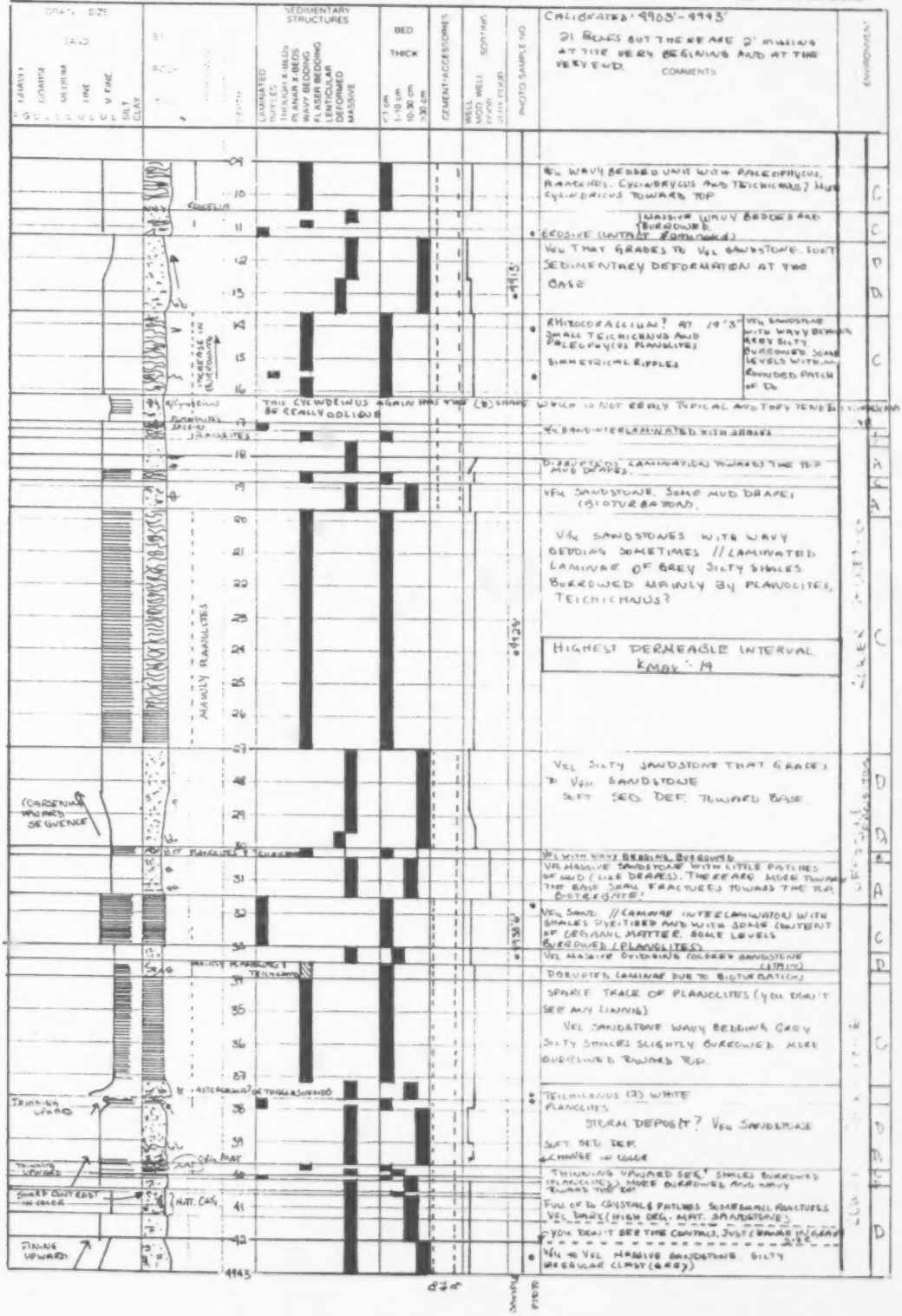
WELL NAME: 1-07-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE JUNE 24, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4887'-4955' CALIBRATED 4892'-4940' KB SLABBED



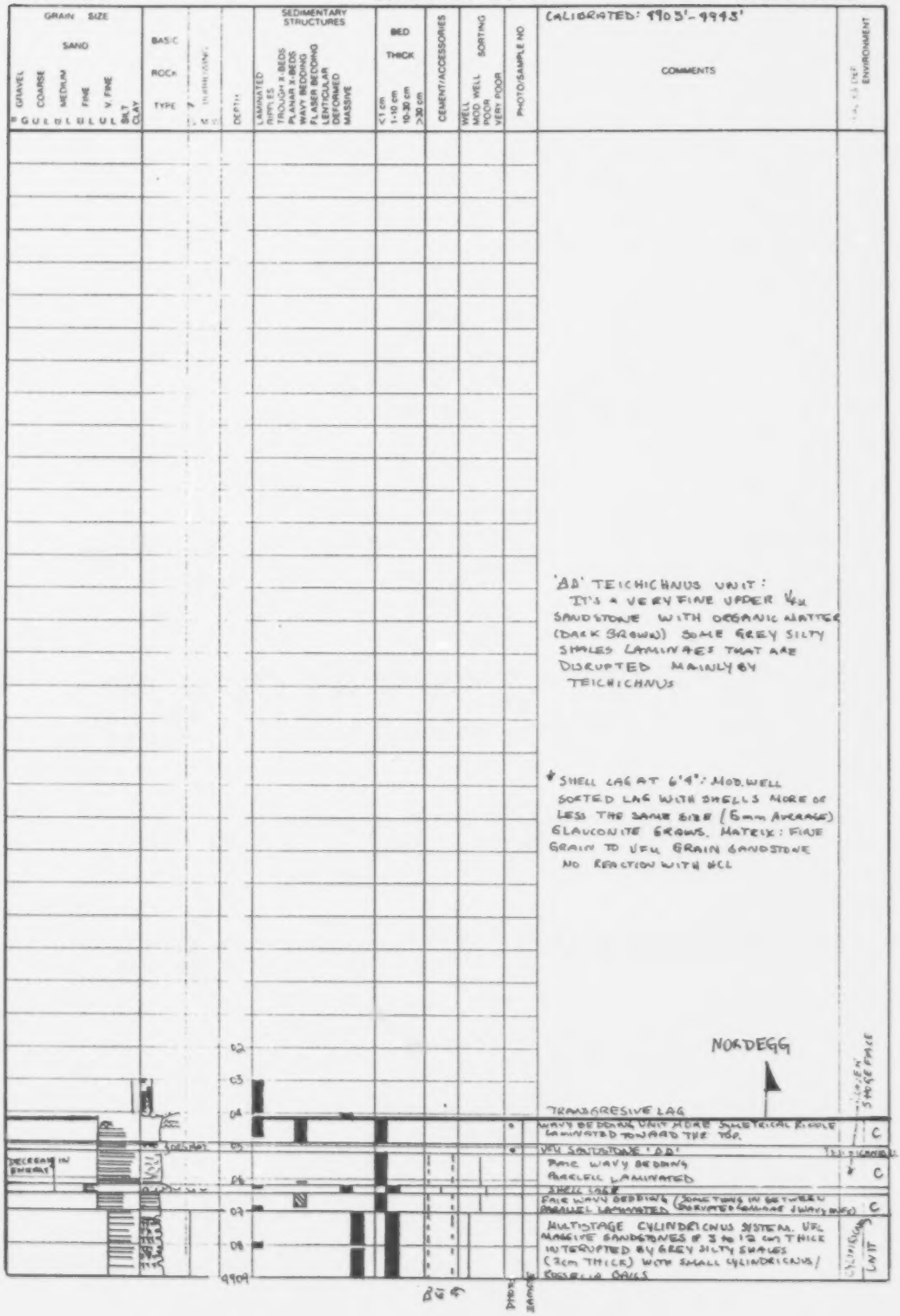
WELL NAME: 3-07-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JUNE 29, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4905'-4945' KB: SLABBED



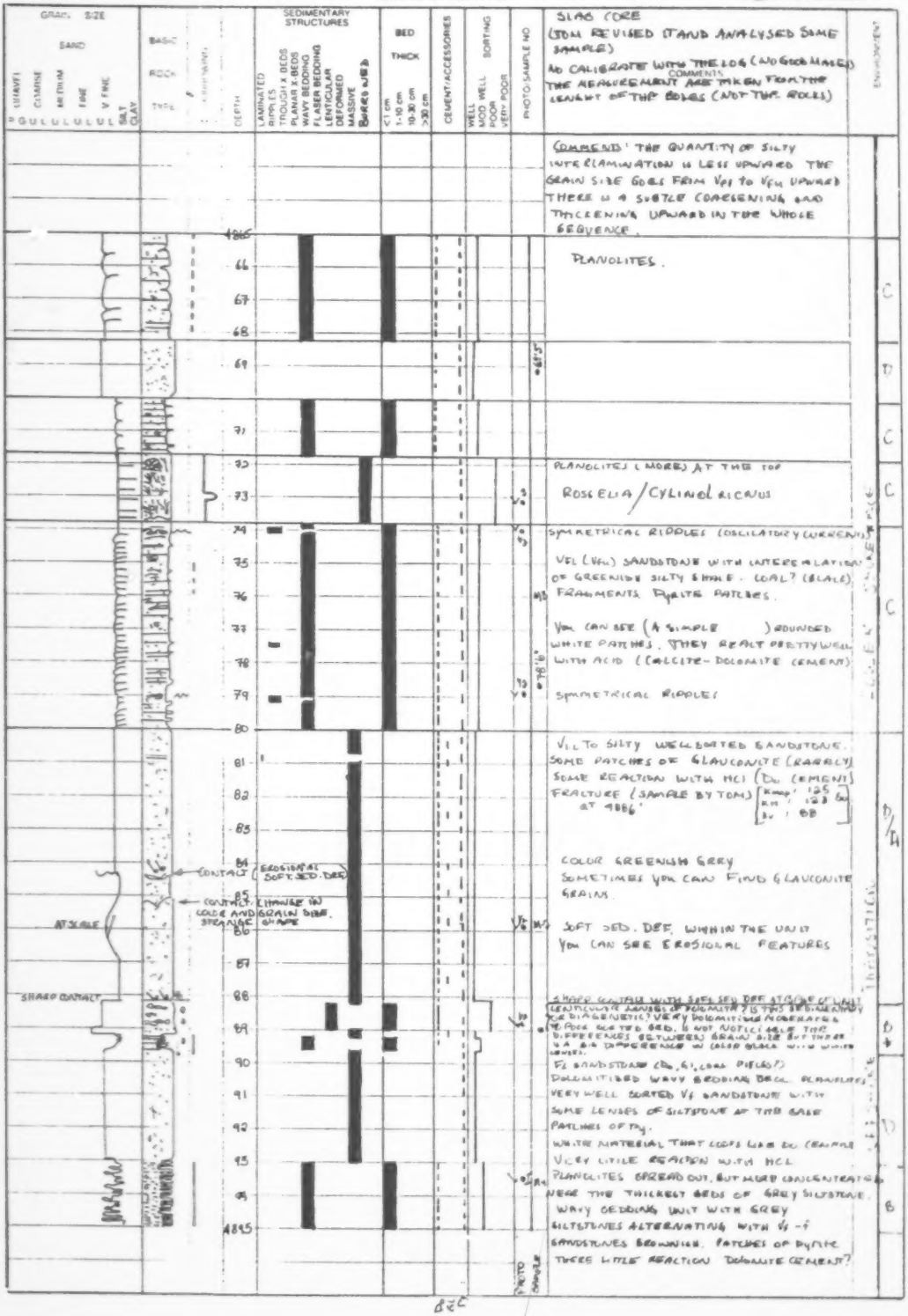
WELL NAME: 3-07-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JUNE 30, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4905'-4945' KB: SLABBED



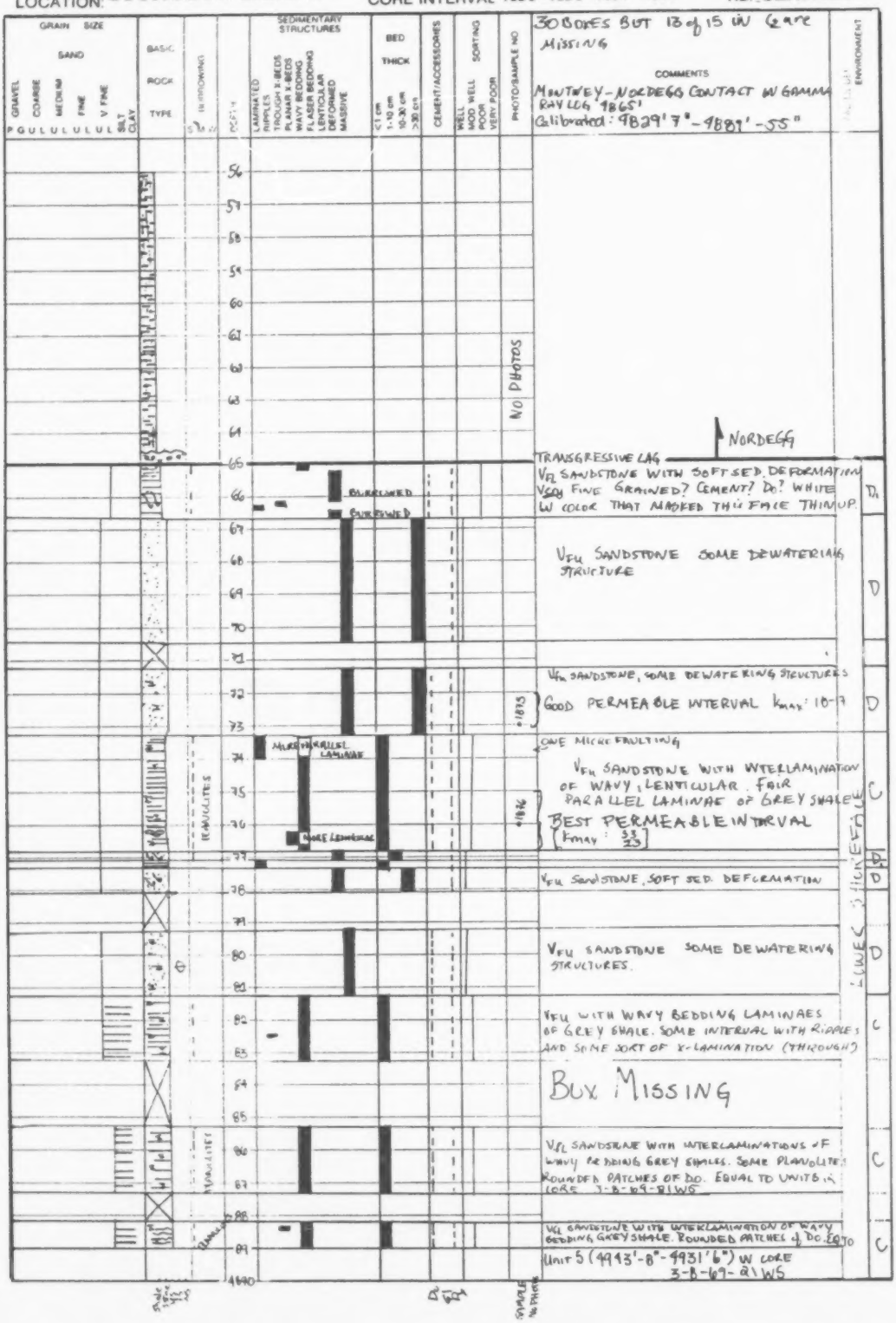
WELL NAME: 5-07-69-21W5 (1 OF 1) FORMATION: MONTNEY DATE: JUNE 4, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4865-4895 KB: SLABBED


GRAIN SIZE
BASIC ROCK TYPE
DEPTH
SEDIMENTARY STRUCTURES
BED THICK
CEMENT/ACCESSORIES
WELL SORTING
PHOTO-SAMPLE NO
SLAB CORE
(TOM REVISED STAND ANALYSED SAME SAMPLE)
NO CALIBRATE WITH THE LOG (AND GOOD MARKS)
COMMENTS
THE MEASUREMENT ARE TAKEN FROM THE LEAVING OF THE BOXES (NOT THE ROLLS)
ENVIRONMENT
COMMENT: THE QUANTITY OF SILTY INTERLAMINATION IS LESS UPWARD THE GRAIN SIZE GOES FROM VFL TO VFU UPWARD THERE IS A SUBTLE COARSENING AND THICKENING UPWARD IN THE WHOLE SEQUENCE.
PLANOLITES.
PLANOLITES (MORE) AT THE TOP
ROSELIA / CYLINDRICUS
SYMMETRICAL RIPPLES (OSCILLATORY CURRENTS)
VFL (VFU) SANDSTONE WITH INTERLAMINATIONS OF GREENISH SILTY SHALE. COAL? (BLACK) FRAGMENTS. PYRITE PATCHES.
YOU CAN SEE (A SIMPLE) ROUNDED WHITE PATCHES. THEY REACT PRETTY WELL WITH ACID (CALCITE-DOLOMITE CEMENT)
SYMMETRICAL RIPPLES
VFL TO SILTY WELL SORTED SANDSTONE. SOME PATCHES OF GLAUCONITE (RARELY) SOME REACTION WITH HCl (Dc CEMENT) FRACTURE (SAMPLE BY TOM) AT 4886'
COLOR GREENISH GREY
SOMETIMES YOU CAN FIND GLAUCONITE GRAINS.
SOFT SED. DEF. WITHIN THE UNIT YOU CAN SEE EROSIONAL FEATURES
SHARP CONTACT
CONTACT
EROSIONAL SOFT SED. DEF.
CONTACT
CHANGE IN COLOR AND GRAIN SIZE. SHARP CONTACT
AT SCALE
SHARP CONTACT WITH SOFT SED DEF AT SCALE OF CORE
FL SANDSTONE (Dc, GL, COAL PIECES?)
DOLOMITIZED WAVY BEDDING BECOMES PLANOLITES
VERY WELL SORTED VF SANDSTONE WITH SOME LENSES OF SILTSTONE AT THE BASE
PATCHES OF PY.
WHITE MATERIAL THAT LOOKS LIKE Dc CEMENT
VERY LITTLE REACTION WITH HCl
PLANOLITES SPREAD OUT, BUT MORE CONCENTRATED NEAR THE THICKEST BEDS OF GREY SILTSTONE.
WAVY BEDDING UNIT WITH GREY SILTSTONES ALTERNATING WITH VF - F SANDSTONES BROWNISH. PATCHES OF PYRITE. THERE LITTLE REACTION DOLOMITE CEMENT?
PHOTO SAMPLE
B2C

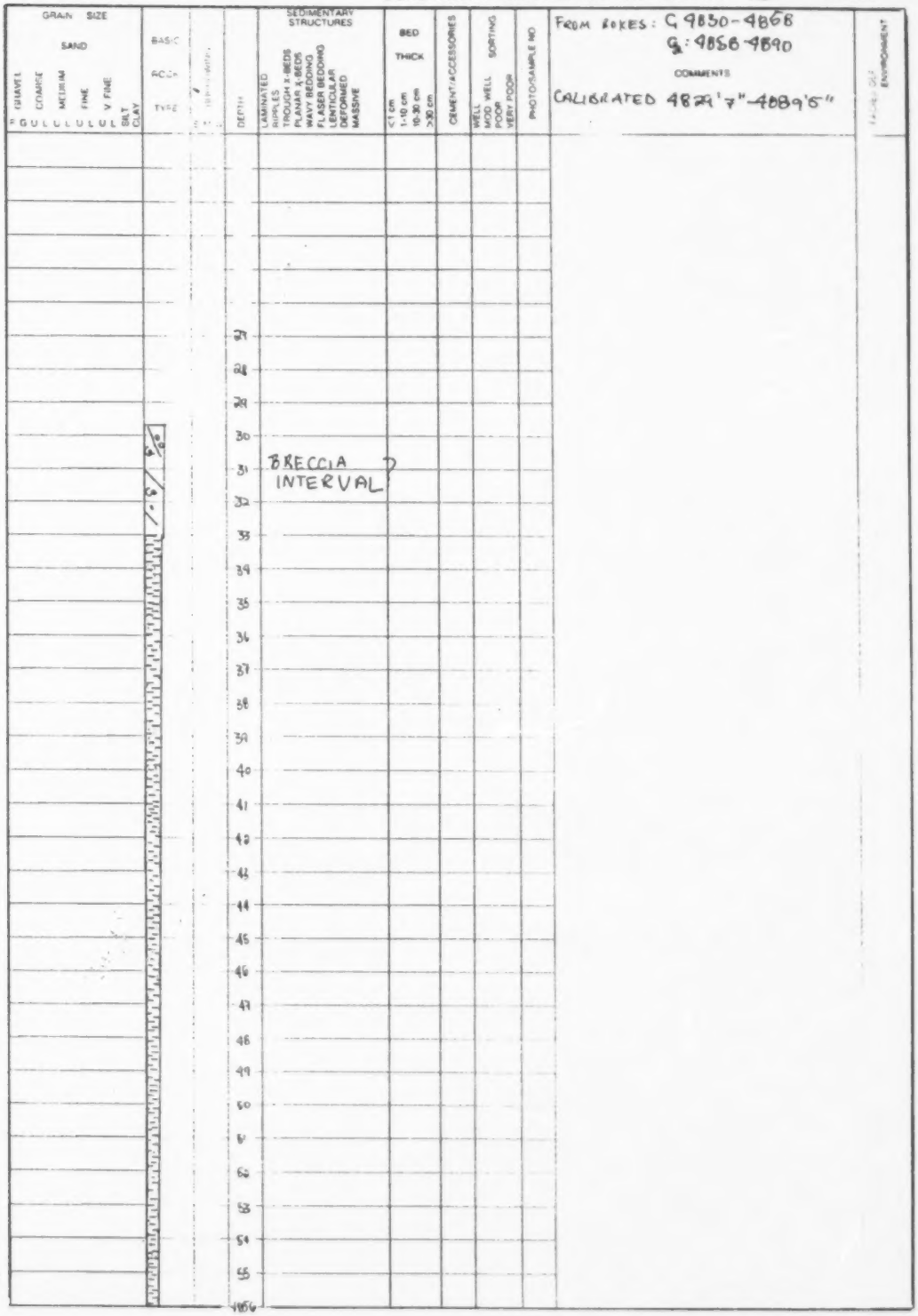
WELL NAME: 7-07-69-21W5 (1 OF 2) FORMATION: MONTNEY / NORDEGG DATE: JULY 15, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4830'-4858' 4858'-4890' KB: SLABBED



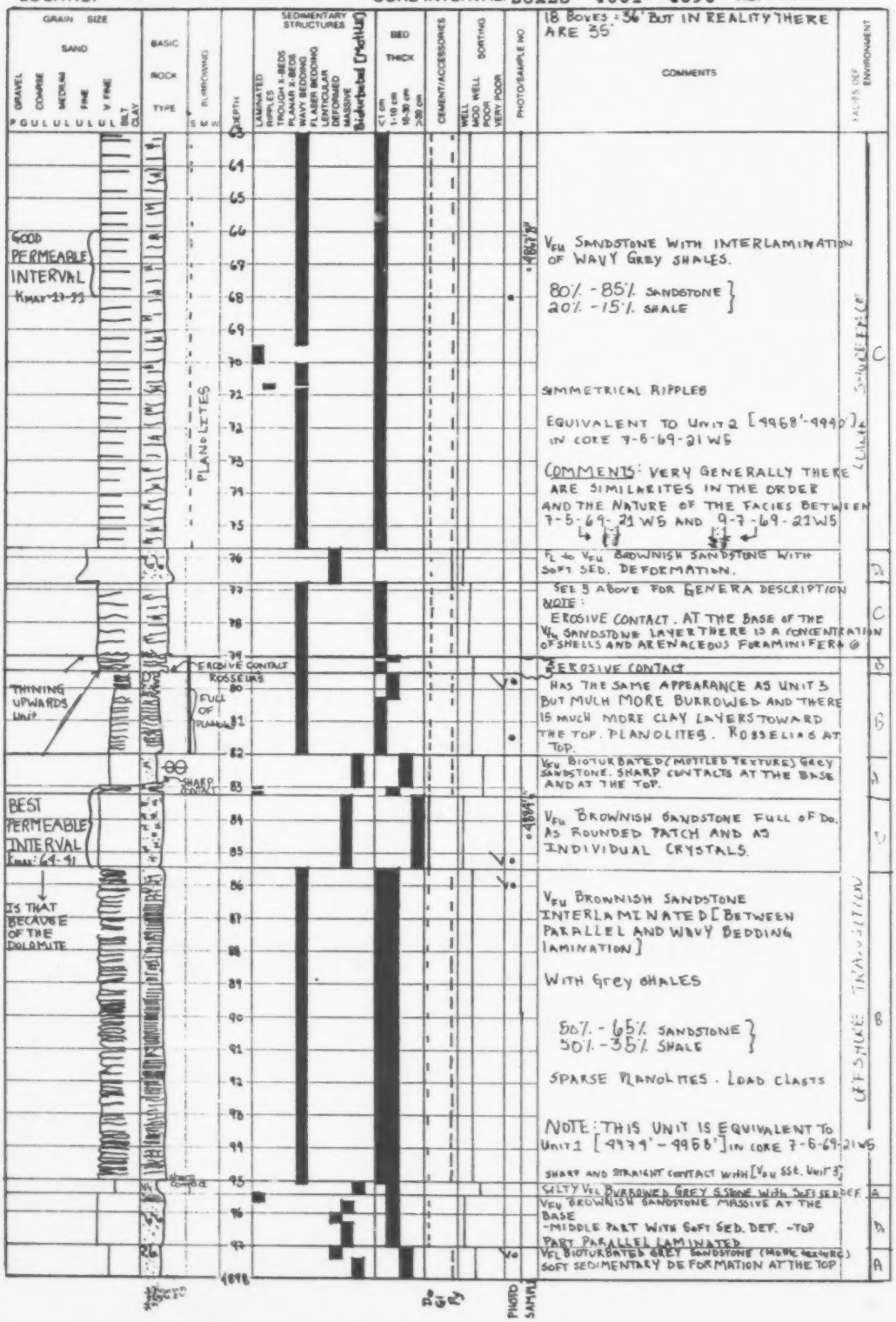
WELL NAME: 7-07-69-21W5 (2 OF 2) FORMATION: MONTNEY / NORDEGG DATE JULY 15, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4830'-4858' 4858'-4890' KB: SLABBED



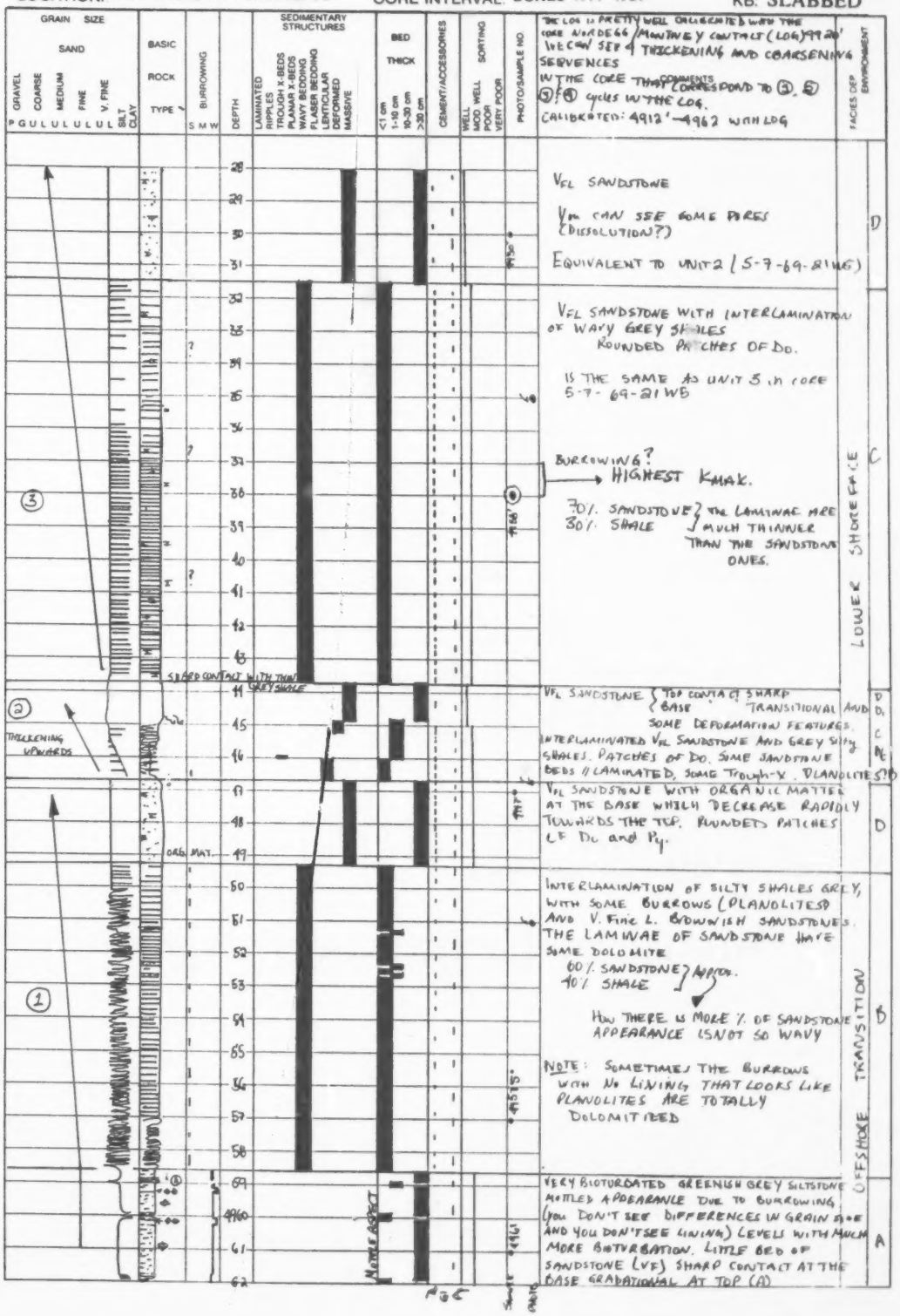
WELL NAME: 9-07-69-21W5 (1 OF 1) FORMATION MONTNEY DATE JULY 19, 1993

LOCATION STURGEON LAKE A CORE INTERVAL: BOXES 4861'-4898' KB: SLABBED


GOOD PERMEABLE INTERVAL
Kmax 23-33
THINING UPWARDS unit
BEST PERMEABLE INTERVAL
Kmax: 64-91
IS THAT BECAUSE OF THE DOLAMITE
PLANOLITES
EROSIVE CONTACT
ROSSELIAS
FULL OF PLANOLITES
SHARP CONTACT
SHARP CONTACT
SHARP AND STRAIGHT CONTACT WITH [VFU SST. UNIT 3]
SILTY VFL BURROWED GREY SSTONE WITH SOFT SED DEF.
VFU BROWNISH SANDSTONE MASSIVE AT THE BASE
-MIDDLE PART WITH SOFT SED. DEF. -TOP PART PARALLEL LAMINATED
VFL BIOTURBATED GREY SANDSTONE (MOTTLED TEXTURE)
SOFT SEDIMENTARY DEFORMATION AT THE TOP
VFU SANDSTONE WITH INTERLAMINATION OF WAVY GREY SHALES.
80% - 85% SANDSTONE
20% - 15% SHALE
SYMMETRICAL RIPPLES
EQUIVALENT TO UNIT 2 [9968'-9990'] IN CORE 7-6-69-21W5
COMMENTS: VERY GENERALLY THERE ARE SIMILARITES IN THE ORDER AND THE NATURE OF THE FACIES BETWEEN 7-6-69-21W5 AND 9-7-69-21W5
FL to VFU BROWNISH SANDSTONE WITH SOFT SED. DEFORMATION.
SEE 5 ABOVE FOR GENERAL DESCRIPTION
NOTE: EROSIVE CONTACT AT THE BASE OF THE VFU SANDSTONE LAYER THERE IS A CONCENTRATION OF SHELLS AND ARENACEOUS FORAMINIFERA
EROSIVE CONTACT
HAS THE SAME APPEARANCE AS UNIT 5 BUT MUCH MORE BURROWED AND THERE IS MUCH MORE CLAY LAYERS TOWARD THE TOP. PLANOLITES. ROSSELIAS AT TOP.
VFU BIOTURBATED (MOTTLED TEXTURE) GREY SANDSTONE. SHARP CONTACTS AT THE BASE AND AT THE TOP.
VFU BROWNISH SANDSTONE FULL OF Do. AS ROUNDED PATCH AND AS INDIVIDUAL CRYSTALS.
VFU BROWNISH SANDSTONE INTERLAMINATED [BETWEEN PARALLEL AND WAVY BEDDING LAMINATION]
WITH GREY SHALES
80% - 65% SANDSTONE
20% - 35% SHALE
SPARSE PLANOLITES. LOAD CASTS
NOTE: THIS UNIT IS EQUIVALENT TO UNIT 1 [9979' - 9968'] IN CORE 7-6-69-21W5
SHOREFACE
OFFSHORE TRANSITION

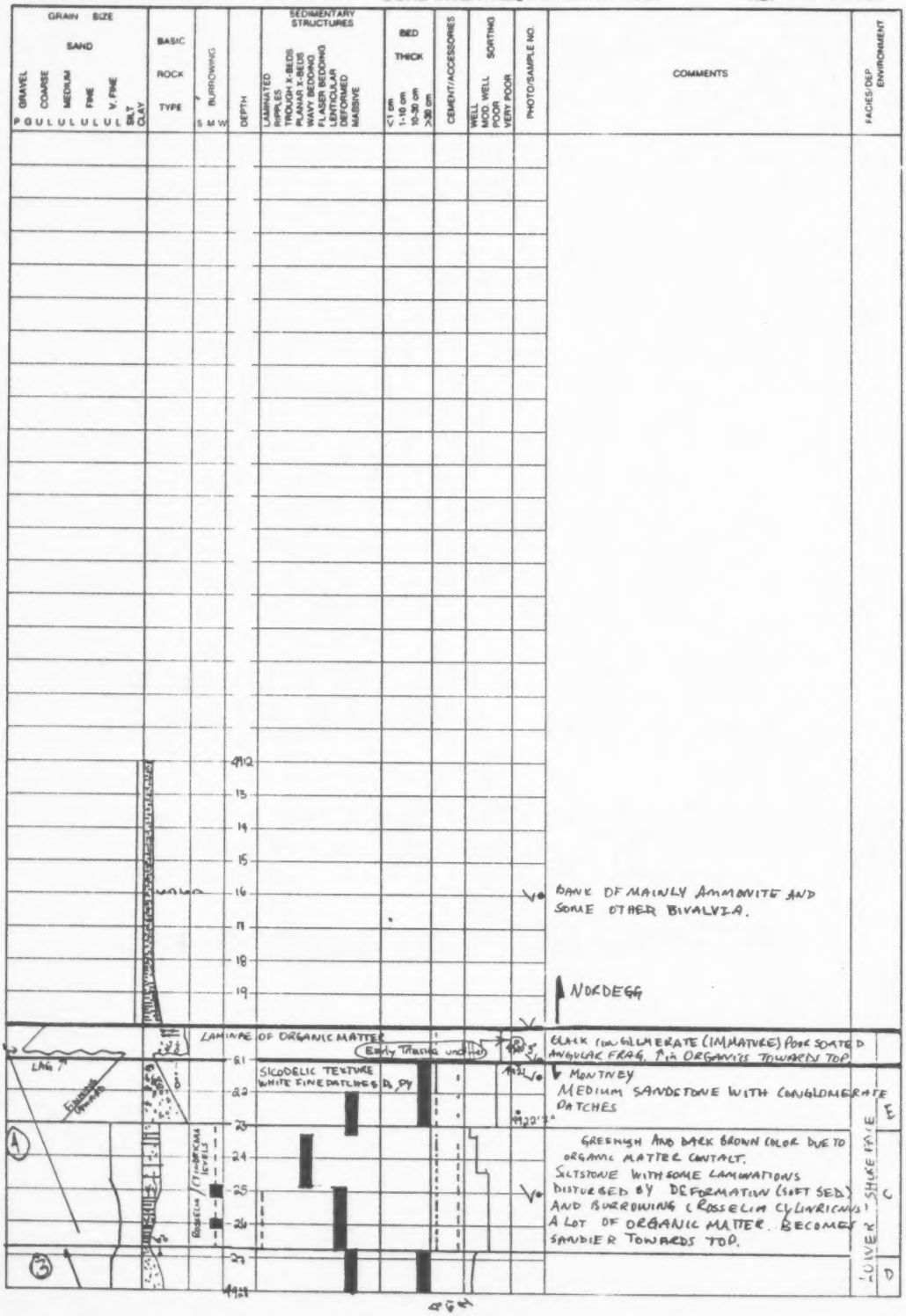
WELL NAME: 3-08-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JUNE 7, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4911'-4961' KB: SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BED THICK
<1 cm
1-10 cm
10-30 cm
>30 cm
CEMENT/ACCESSORIES
SORTING
WELL
MOD WELL
POOR
VERY POOR
PHOTO/SAMPLE NO.
FACIES DEP ENVIRONMENT
THE LOG IS PRETTY WELL CORRELATED WITH THE CORE N/A DEGG/MONTNEY CONTACT (LOG) 4920' WE CAN SEE A THICKENING AND COARSENING SERVENCES IN THE CORE THAT CORRESPOND TO ③, ② & ① CYCLES IN THE LOG.
CALIBRATED: 4912'-4962' WITH LOG
COMMENTS
VFL SANDSTONE
VM CAN SEE SOME PORES (DISSOLUTION?)
EQUIVALENT TO UNIT 2 (5-7-69-21W5)
VFL SANDSTONE WITH INTERLAMINATION OF WAVY GREY SHALES
ROUNDED PATCHES OF Do.
IS THE SAME AS UNIT 3 IN CORE 5-7-69-21W5
BURROWING?
HIGHEST KMAK.
70% SANDSTONE } THE LAMINAE ARE
30% SHALE } MUCH THINNER THAN THE SANDSTONE ONES.
SHARP CONTACT WITH THAT GREY SHALE
VFL SANDSTONE { TOP CONTACT SHARP BASE TRANSITIONAL AND SOME DEFORMATION FEATURES.
INTERLAMINATED VFL SANDSTONE AND GREY SILTY SHALES. PATCHES OF Do. SOME SANDSTONE BEDS // LAMINATED, SOME TROUGH-X. PLANOLITES?
THICKENING UPWARDS
ORG. MAT.
VFL SANDSTONE WITH ORGANIC MATTER AT THE BASE WHICH DECREASE RAPIDLY TOWARDS THE TOP. ROUNDED PATCHES OF Do and Py.
INTERLAMINATION OF SILTY SHALES GREY, WITH SOME BURROWS (PLANOLITES?) AND V. FINE L. BROWNISH SANDSTONES. THE LAMINAE OF SANDSTONE HAVE SOME DOLOMITE
60% SANDSTONE } APPROX.
40% SHALE }
HOW THERE IS MORE % OF SANDSTONE APPEARANCE IS NOT SO WAVY
NOTE: SOMETIMES THE BURROWS WITH NO LINING THAT LOOKS LIKE PLANOLITES ARE TOTALLY DOLOMITIZED
VERY BIOTURBATED GREENISH GREY SILTSTONE MOTTLED APPEARANCE DUE TO BURROWING (YOU DON'T SEE DIFFERENCES IN GRAIN SIZE AND YOU DON'T SEE LINING) LEVELS WITH MUCH MORE BIOTURBATION. LITTLE BED OF SANDSTONE (VFL) SHARP CONTACT AT THE BASE GRADATIONAL AT TOP (A)
LOWER SHOREFACE
OFFSHORE TRANSITION
MOTTLED ASPECT
4960
4915'
4961'
ROC
SAMP
PHOTO

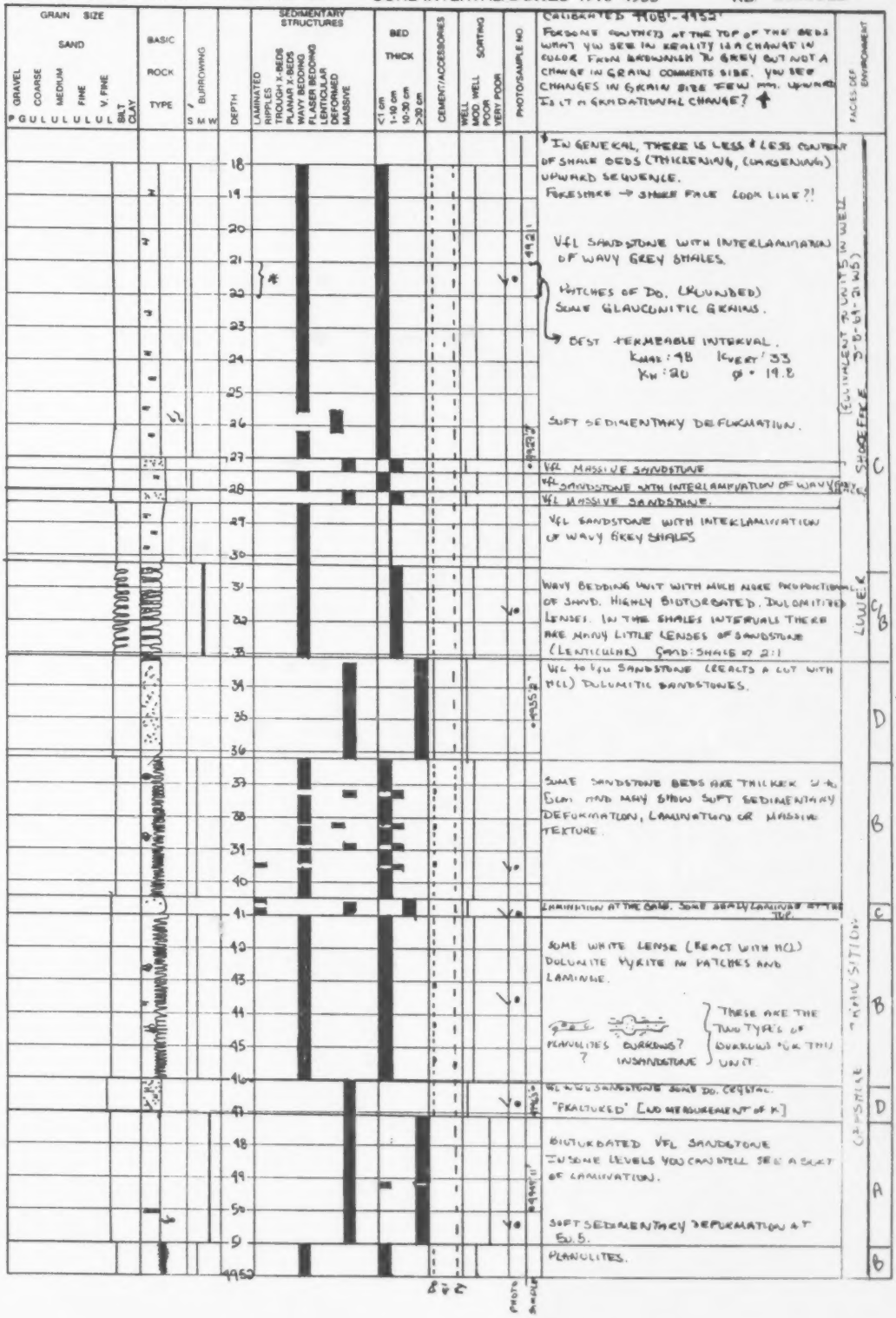
WELL NAME: 3-08-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JUNE 8, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4911'-4961' KB: SLABBED



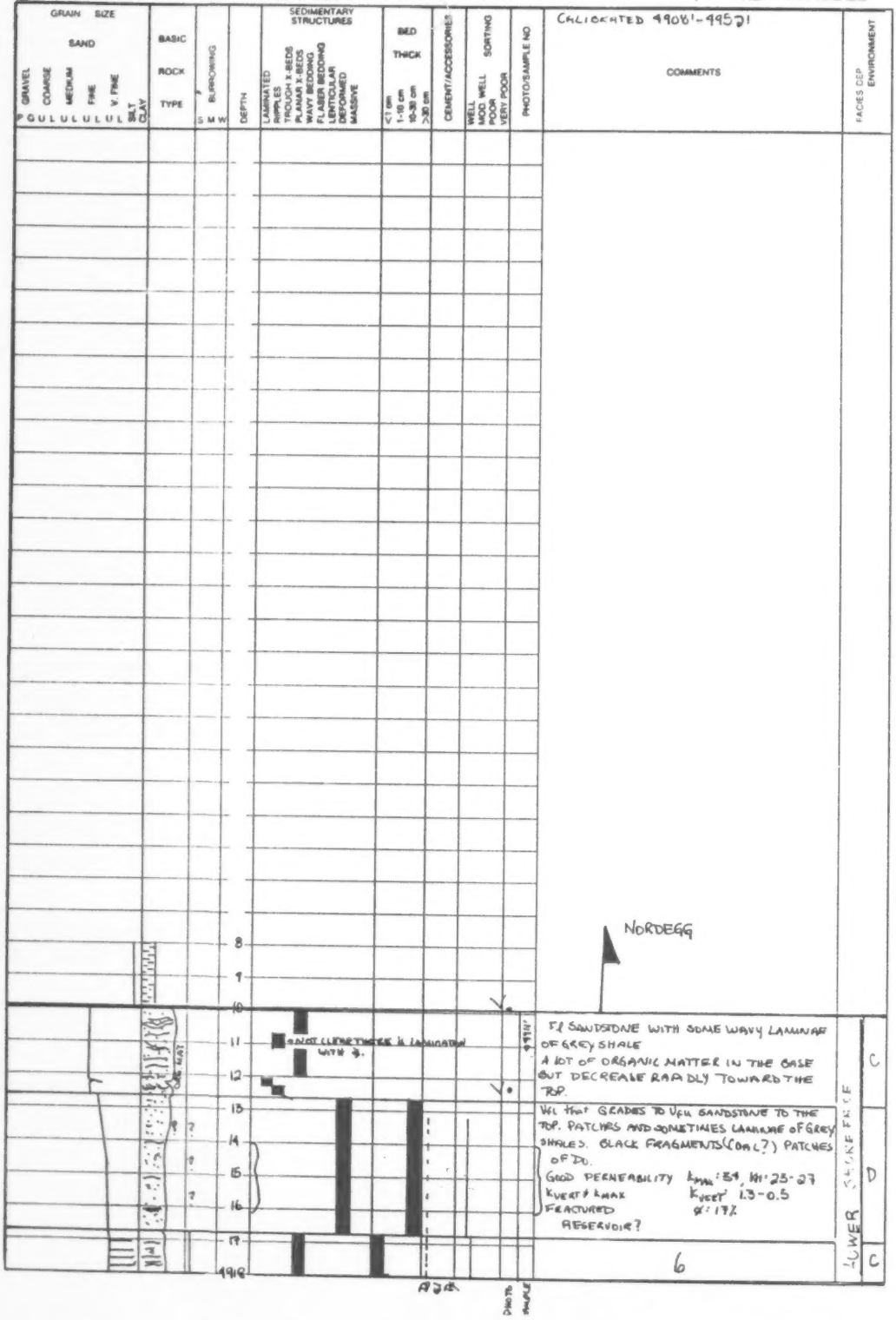
WELL NAME: 5-08-69-21W5 (1 of 2) FORMATION: MONTNEY DATE JUNE 9, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4910'-4955' KB: SLABBED



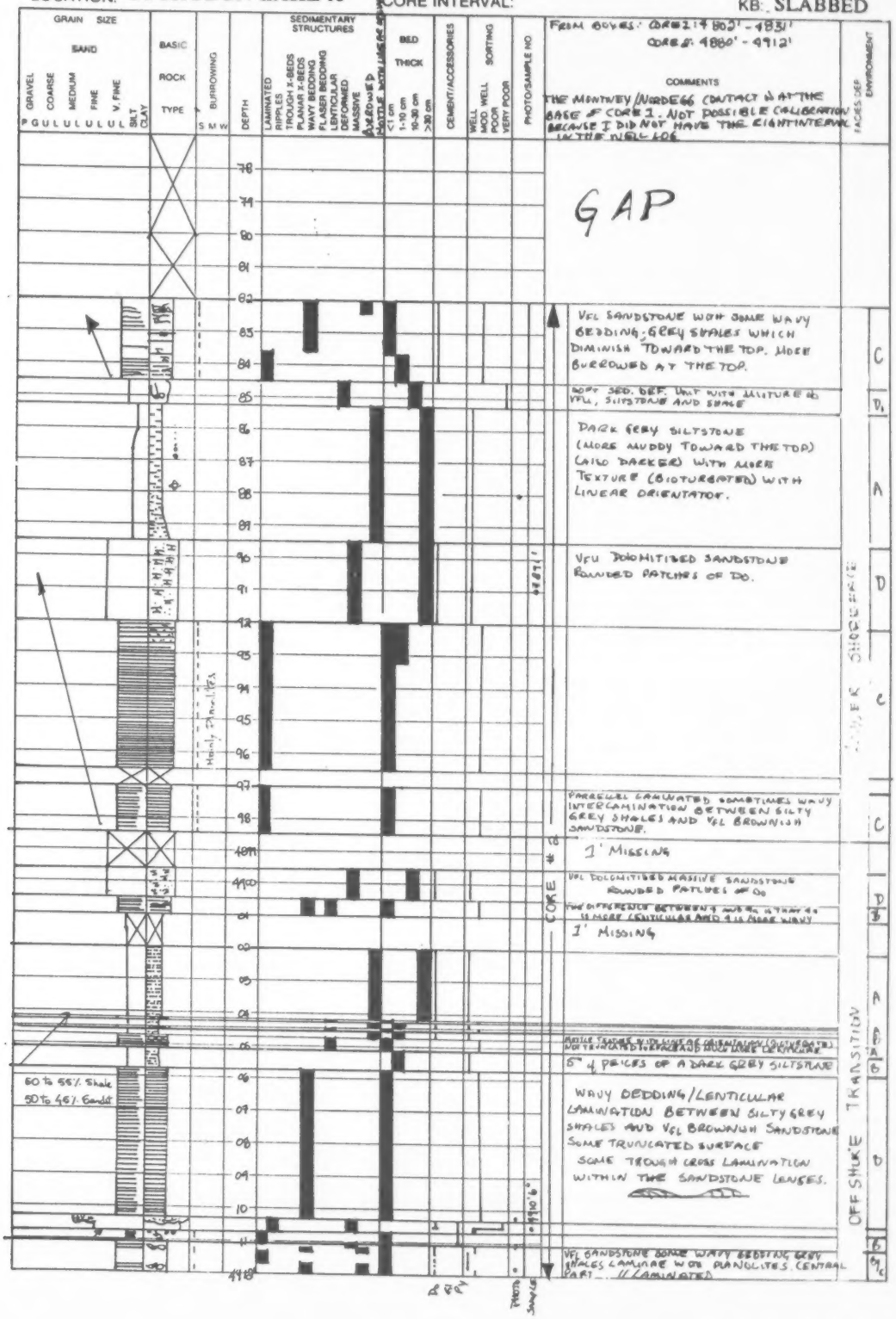
WELL NAME: 05-08-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: JUNE 9, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4910'-4955' KB: SLABBED



WELL NAME: 11-08-69-21W5 (1 OF 4) FORMATION: MONTNEY DATE: JULY 29, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: KB: SLABBED


GRAIN SIZE
SAND
GRAVEL
COARSE
MEDIUM
FINE
V. FINE
SILT
CLAY
BASIC ROCK TYPE
BURROWING
DEPTH
SEDIMENTARY STRUCTURES
LAMINATED
RIPPLES
TROUGH X-BEDS
PLANAR X-BEDS
WAVY BEDDING
FLASER BEDDING
LENTICULAR
DEFORMED
MASSIVE
BED THICK
CEMENT/ACCESSORIES
SORTING
WELL
MOD WELL
POOR
VERY POOR
PHOTO/SAMPLE NO
FROM ABOVE: CORE 1: 4805' - 4851'
CORE 2: 4880' - 4912'
COMMENTS
THE MONTNEY/HORDEGG CONTACT IS AT THE BASE OF CORE 1. NOT POSSIBLE CALIBRATION BECAUSE I DID NOT HAVE THE GIANTINTERVAL IN THE WELL LOG
FACIES DEP ENVIRONMENT
GAP
VFL SANDSTONE WITH SOME WAVY BEDDING; GREY SHALES WHICH DIMINISH TOWARD THE TOP. MORE BURROWED AT THE TOP.
SOFT SED. DEF. UNIT WITH MIXTURE OF VFL, SILTSTONE AND SHALE
DARK GREY SILTSTONE (MORE MUDDY TOWARD THE TOP) (ALSO DARKER) WITH MORE TEXTURE (BIOTURBATED) WITH LINEAR ORIENTATION.
VFL DOLOMITIZED SANDSTONE ROUNDED PATCHES OF DO.
LOWER SHOREFACE
PARALLEL LAMINATED SOMETIMES WAVY INTERLAMINATION BETWEEN SILTY GREY SHALES AND VFL BROWNISH SANDSTONE.
1' MISSING
CORE #2
VFL DOLOMITIZED MASSIVE SANDSTONE ROUNDED PATCHES OF DO
THE DIFFERENCE BETWEEN 4 AND 5 IS THAT 4 IS MORE LENTICULAR AND 5 IS MORE WAVY
1' MISSING
OFFSHORE TRANSITION
5' 4 PIECES OF A DARK GREY SILTSTONE
WAVY BEDDING/LENTICULAR LAMINATION BETWEEN SILTY GREY SHALES AND VFL BROWNISH SANDSTONE SOME TRUNCATED SURFACE SOME TROUGH CROSS LAMINATION WITHIN THE SANDSTONE LENSES.
VFL SANDSTONE SOME WAVY BEDDING GREY SHALES LAMINAE W/ OR PLANOLITES CENTRAL PART // LAMINATED
60 To 55% Shale
50 To 45% Sandst
Mainly Planolites
PHOTO SAMPLE

WELL NAME: 11-08-69-21W5 (2 OF 4) FORMATION: MONTNEY / NORDEGG DATE: JULY 29, 1993

LOCATION: **STURGEON LAKE A** CORE INTERVAL: KB: SLABBED

GRAIN SIZE: GRAVEL / SAND: COARSE, MEDIUM, FINE, V. FINE / SILT / CLAY	BASIC ROCK TYPE	BURROWING: S, M, W	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED, RIPPLES, TROUGH X-BEDS, PLANAR X-BEDS, WAVY BEDDING, FLASER BEDDING, LENTICULAR, DEFORMED, MASSIVE	BED THICK: <1 cm, 1-10 cm, 10-30 cm, >30 cm	CEMENT/ACCESSORIES	SORTING: WELL, MOD WELL, POOR, VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES DEP ENVIRONMENT
			43						From Boxes: Core 1: 4802'-4835' Core 2: 4880'-4912' THE MONTNEY/NORDEGG CONTACT IS AT THE BASE OF CORE 1. NOT CALIBRATED BECAUSE I DON'T HAVE THE RIGHT INTERVAL IN THE WELL LOG.	
			44							
			45							
			46							
			47							
			48							
			49							
			50							
			51							
			52							
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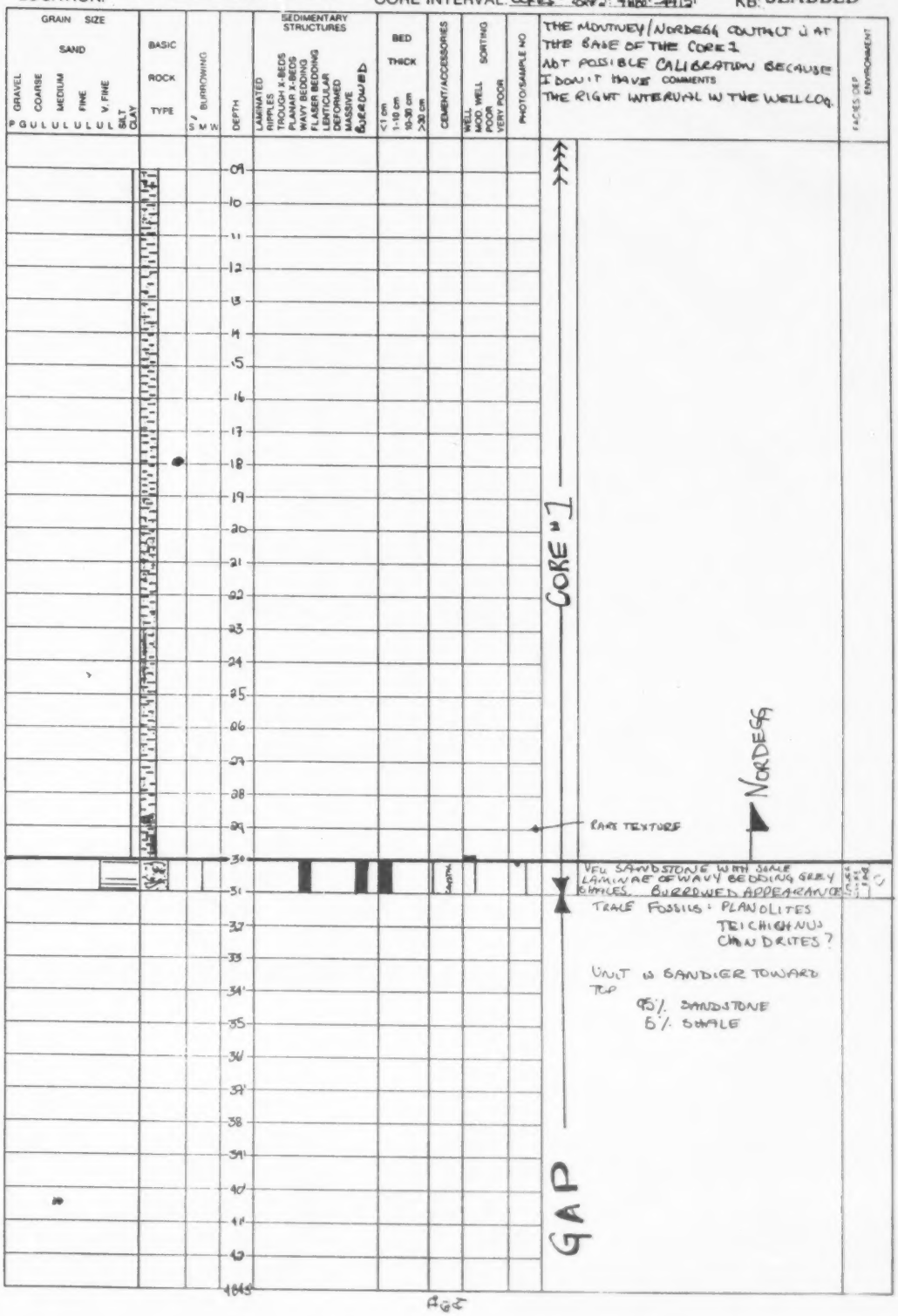
			73							
			74							
			75							
			76							
			77							
			100							

GAP

WELL NAME: 11-08-69-21W5 (3 OF 4) FORMATION: MONTNEY / NORDEGG DATE JULY 29, 1993

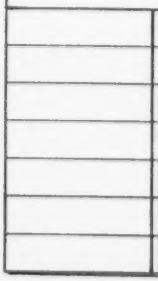
LOCATION: STURGEON LAKE A CORE INTERVAL: ~~CORE 1: 4802'-4903'~~ CORE 1: 4802'-4903' CORE 2: 4880'-4912' KB: SLABBED



WELL NAME: 11-08-69-21W5 (4 OF 4) FORMATION: MONTNEY / NORDEGG DATE JULY 29, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: CORE 1: 4803'-4831' CORE 2: 4880'-4912' KB: SLABBED

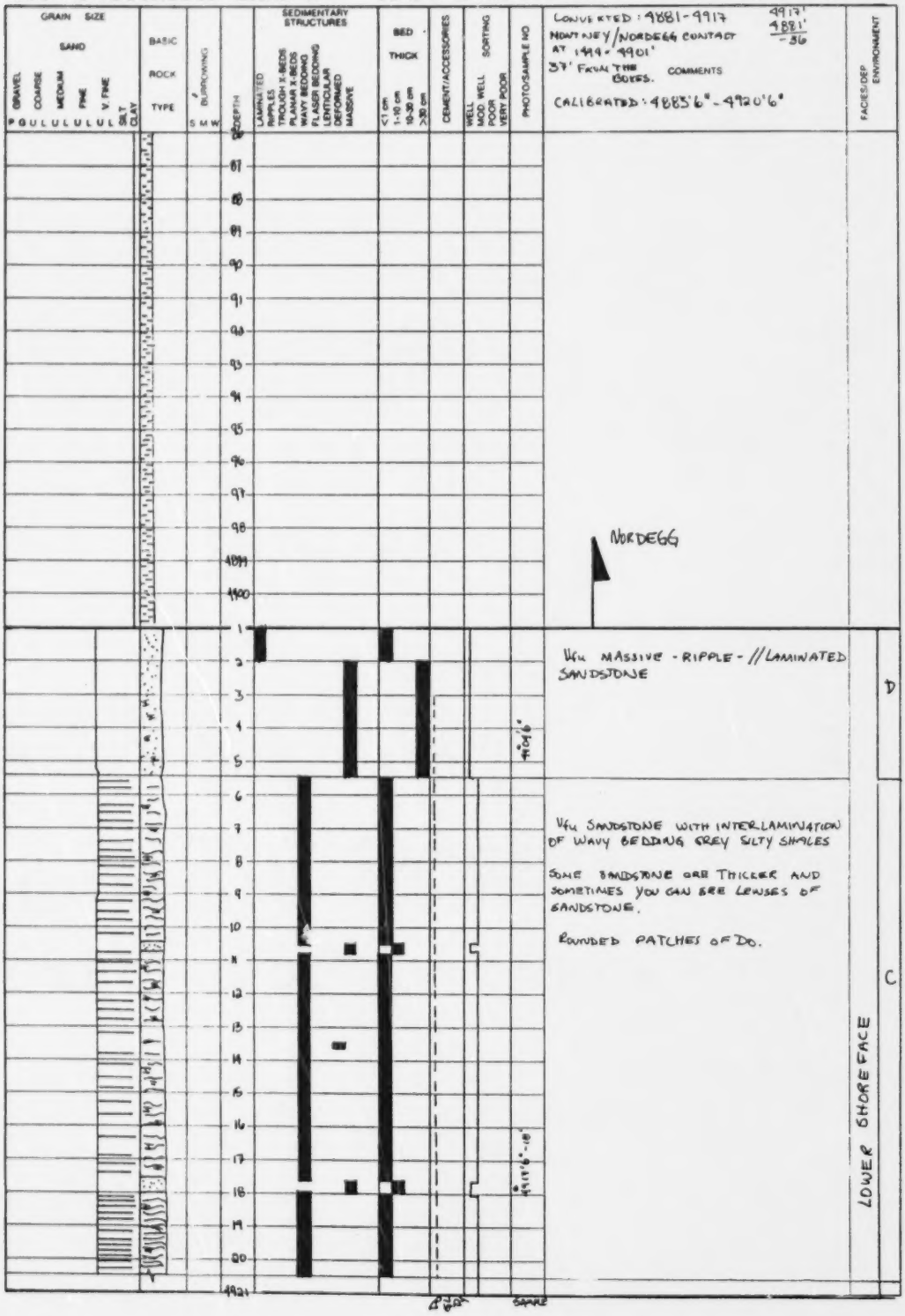
GRAIN SIZE: GRAVEL / SAND: COARSE, MEDIUM, FINE, V FINE / SILT / CLAY	BASIC ROCK TYPE	BURROWING: S, M, W	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED, RIPPLES, TROUGH X-BEDS, PLANAR X-BEDS, WAVY BEDDING, FLASER BEDDING, LENTICULAR, DEFORMED, MASSIVE	BED THICK: <1 cm, 1-10 cm, 10-30 cm, >30 cm	CEMENT/ACCESSORIES	SORTING: WELL, MOD WELL, POOR, VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES DEPOSITIONAL ENVIRONMENT
									THE MONTNEY / Nordegg CONTACT AT BASE OF CORE 1. NOT CALIBRATED.	



CORE #1

WELL NAME: 5-18-69-21W5 (1 OF 2) FORMATION: MONTNEY DATE: JULY 29, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 1487.75m-1498.75m KB NOT SLABBED



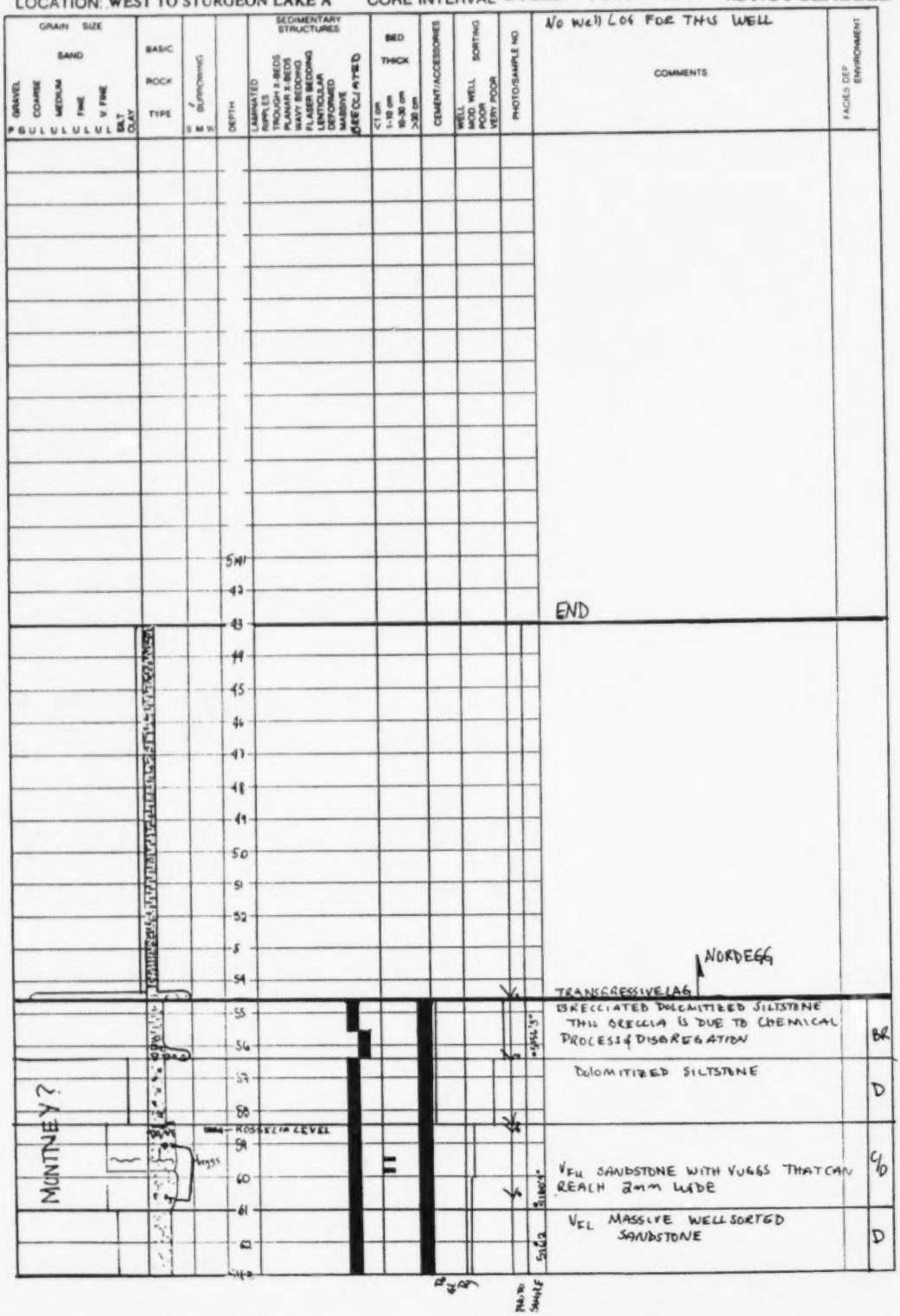
WELL NAME: 5-18-69-21W5 (2 OF 2) FORMATION: MONTNEY DATE: AUG. 4, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4883'6"-4920'6" KB NOT SLABBED

GRAIN SIZE: P GRAVEL	G COARSE	U MEDIUM	L FINE	U V. FINE	L SILT	U CLAY	BASIC ROCK TYPE	BURROWING: S	M	W	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED	RIPPLES	TROUGH X-BEDS	PLANAR X-BEDS	WAVY BEDDING	FLASER BEDDING	LENTICULAR	DEFORMED	MASSIVE	BED THICK: <1 cm	1-10 cm	>30 cm	CEMENT/ACCESSORIES	SORTING: WELL	MOD. WELL	POOR	VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES DEP ENVIRONMENT

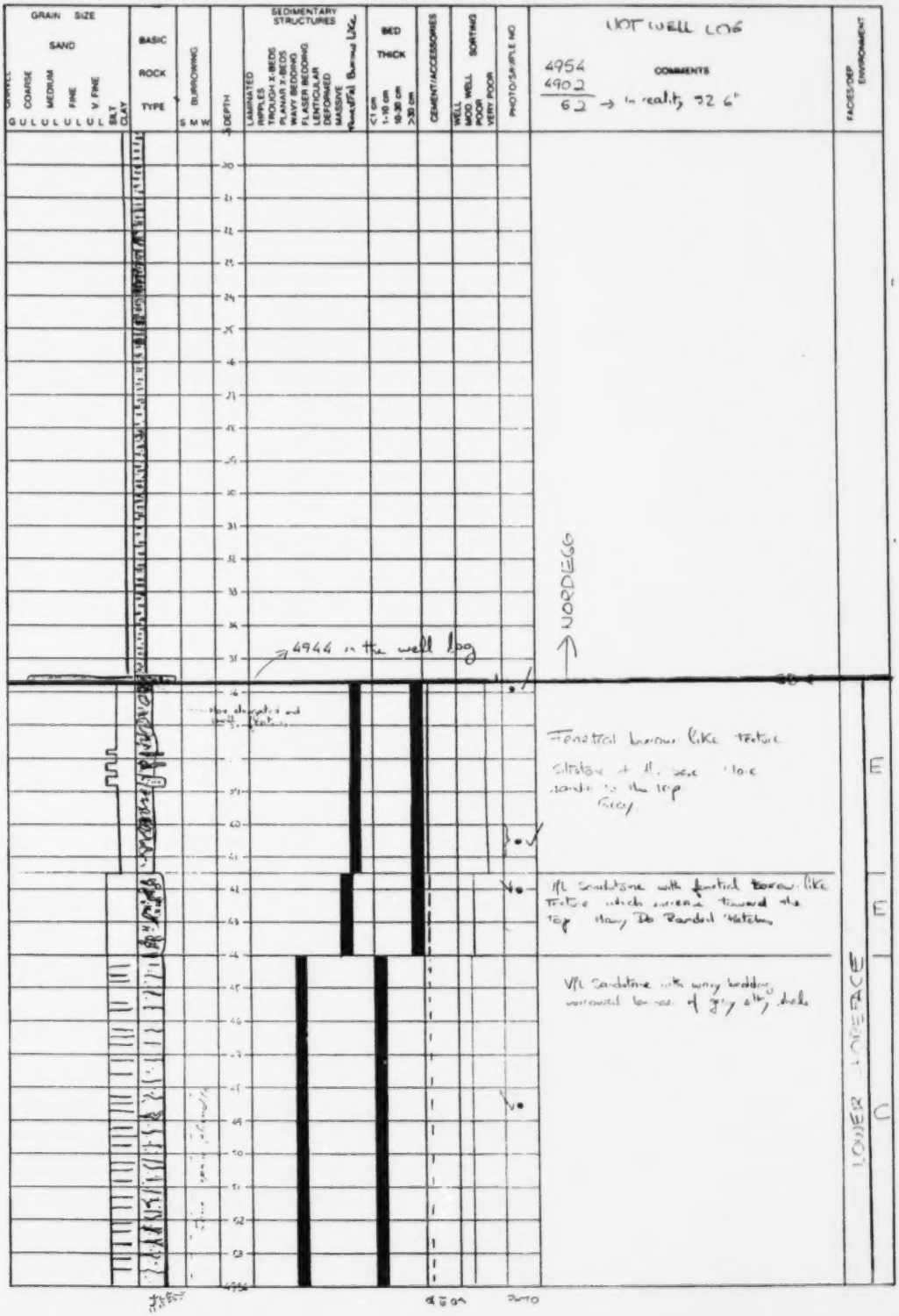
WELL NAME: 9-04-69-22W5 (1 OF 1) FORMATION: MONTNEY ??? DATE: AUG. 4, 1993

LOCATION: WEST TO STURGEON LAKE A CORE INTERVAL BOXES 5141'-5163' KB NOT SLABBED



WELL NAME: 9-11-69-22W5 (1 OF 2) FORMATION: MONTNEY DATE: AUG. 5, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4902'-4954' KB: NOT SLABBED



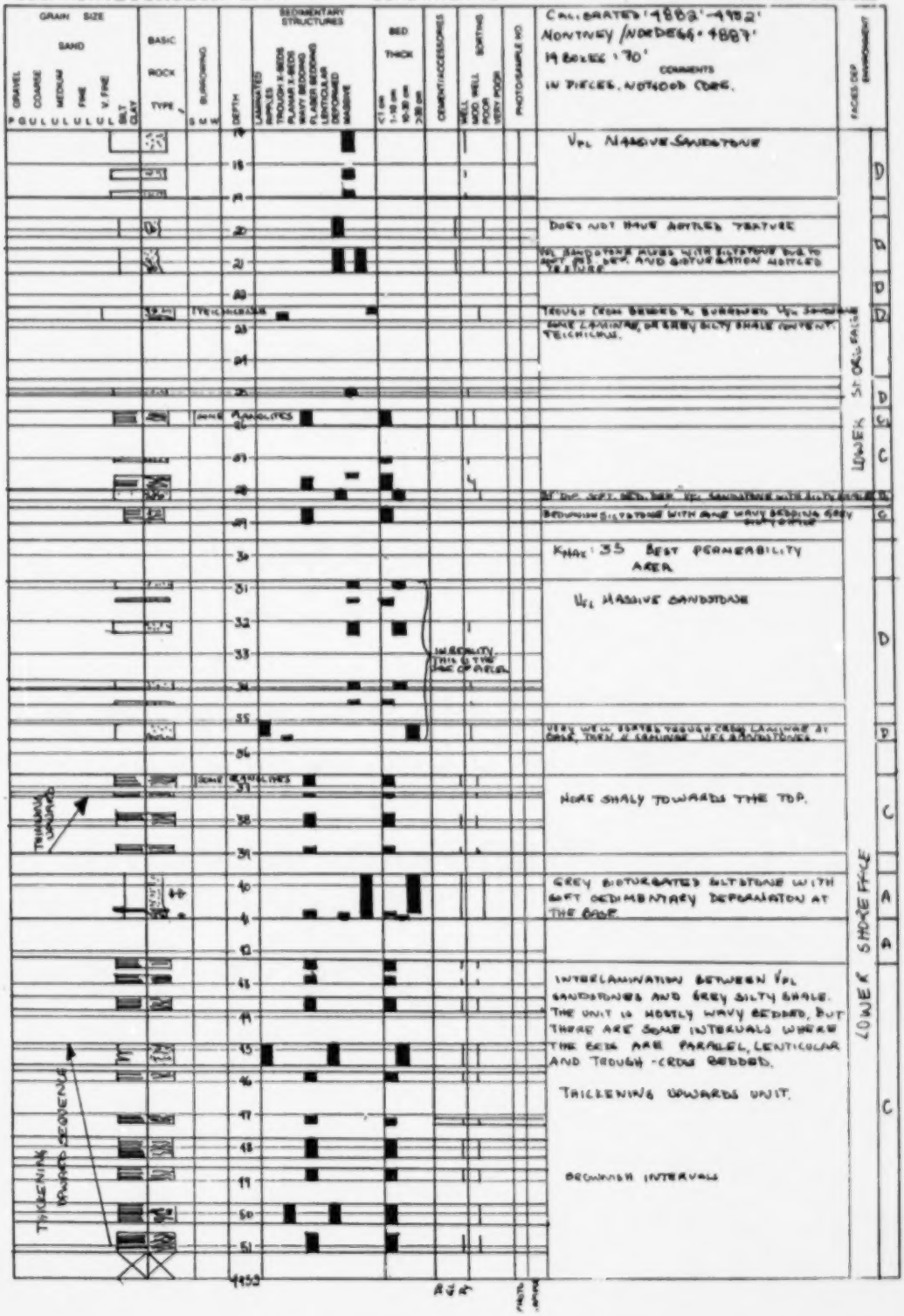
WELL NAME: 9-11-69-22W5 (2 OF 2) FORMATION: MONTNEY DATE: AUG. 5, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4902'-4954' KB: NOT SLABBED

GRAIN SIZE: GRAVEL	GRAIN SIZE: SAND: COARSE	GRAIN SIZE: SAND: MEDIUM	GRAIN SIZE: SAND: FINE	GRAIN SIZE: SAND: V. FINE	GRAIN SIZE: SILT	GRAIN SIZE: CLAY	BASIC ROCK TYPE	BURROWING: SP	BURROWING: M	BURROWING: W	DEPTH	SEDIMENTARY STRUCTURES: LAMINATED	SEDIMENTARY STRUCTURES: RIPPLES	SEDIMENTARY STRUCTURES: TROUGH X-BEDS	SEDIMENTARY STRUCTURES: PLANAR X-BEDS	SEDIMENTARY STRUCTURES: WAVY BEDDING	SEDIMENTARY STRUCTURES: FLASER BEDDING	SEDIMENTARY STRUCTURES: LENTICULAR	SEDIMENTARY STRUCTURES: DEFORMED	SEDIMENTARY STRUCTURES: MASSIVE	BED THICK: <1 cm	BED THICK: 1-10 cm	BED THICK: 10-30 cm	BED THICK: >30 cm	CEMENT/ACCESSORIES	SORTING: WELL	SORTING: MOD.	SORTING: POOR	SORTING: VERY POOR	PHOTO/SAMPLE NO	COMMENTS	FACIES/DEP. ENVIRONMENT

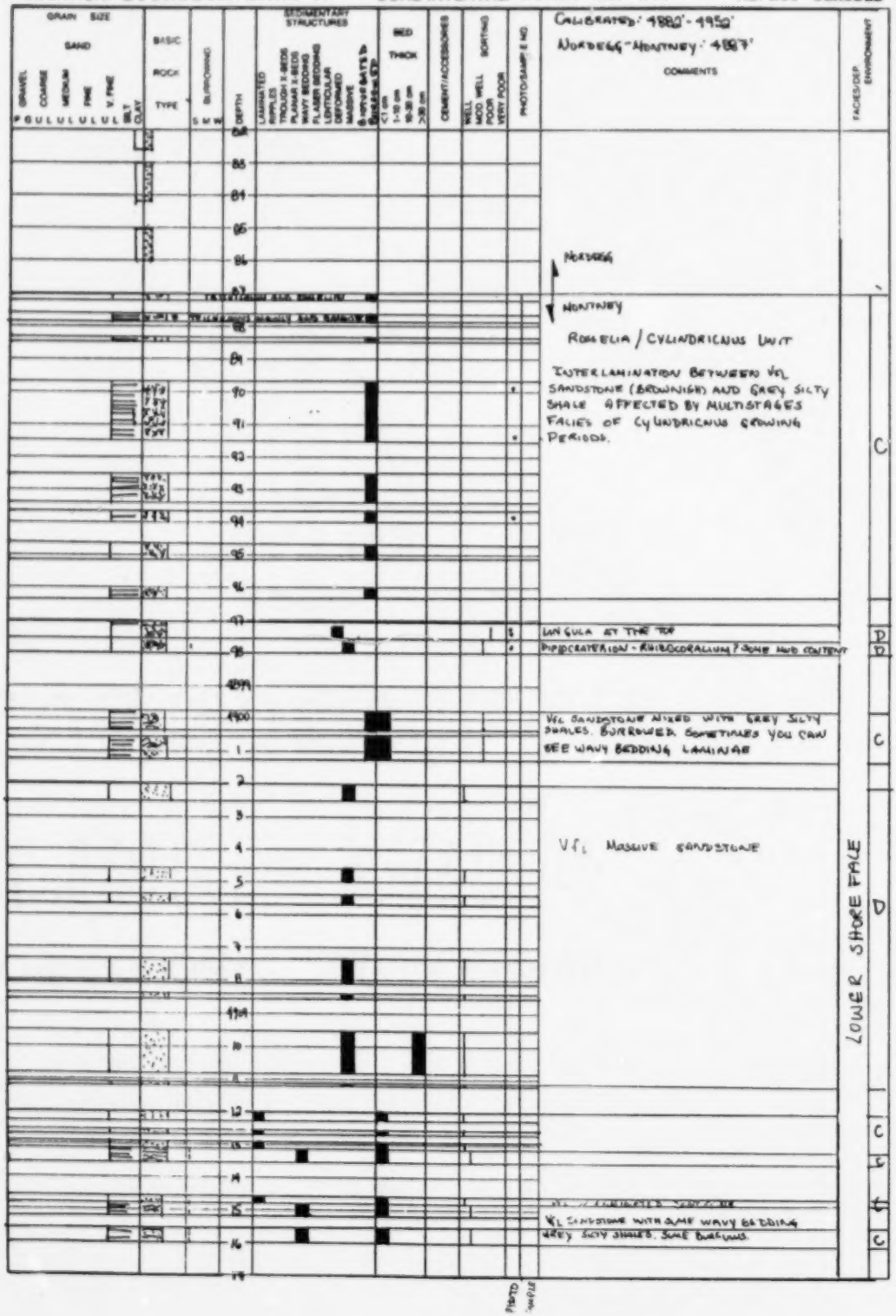
WELL NAME: 01-12-69-22W5 (1 OF 2) FORMATION: MONTNEY DATE: AUG. 9, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4881'-4951' KB: NOT SLABBED



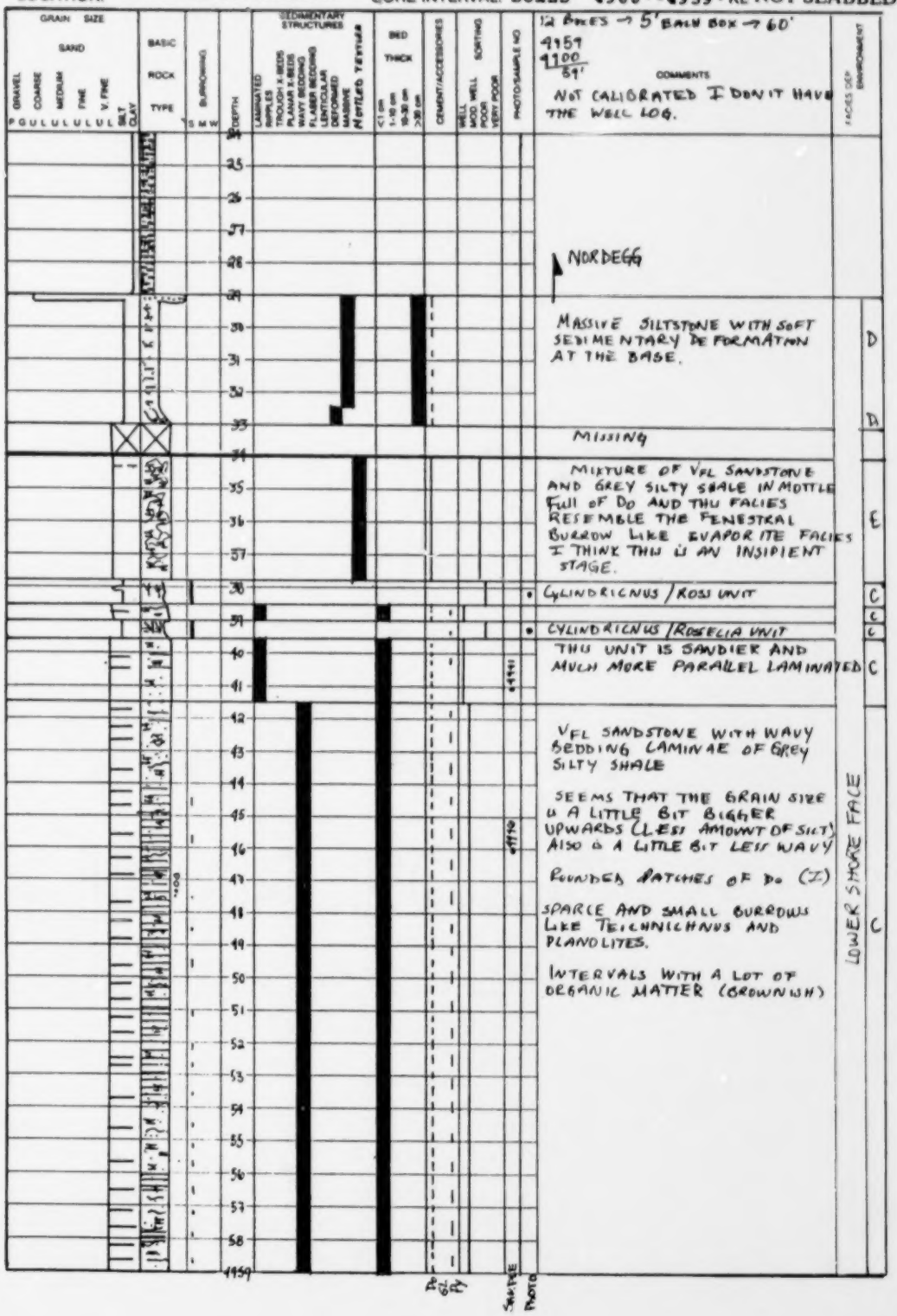
WELL NAME: 01-12-69-22W5 (2 OF 2) FORMATION: MONTNEY DATE AUG. 9, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4881'-4951' KB: NOT SLABBED



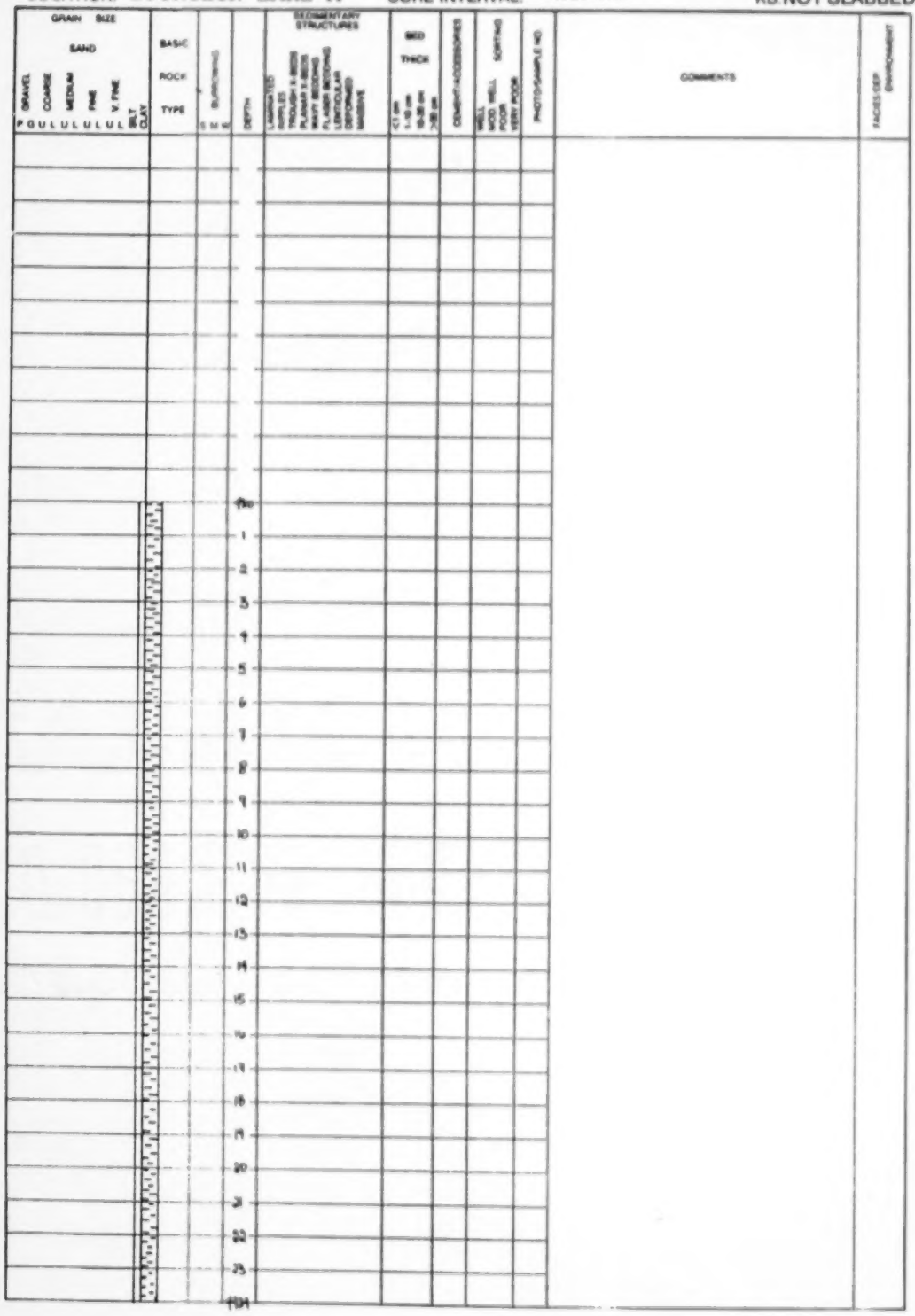
WELL NAME: 5-12-69-22W5 (1 OF 2) FORMATION: MONTNEY DATE: AUG. 23 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: BOXES 4900'-4959' KE NOT SLABBED



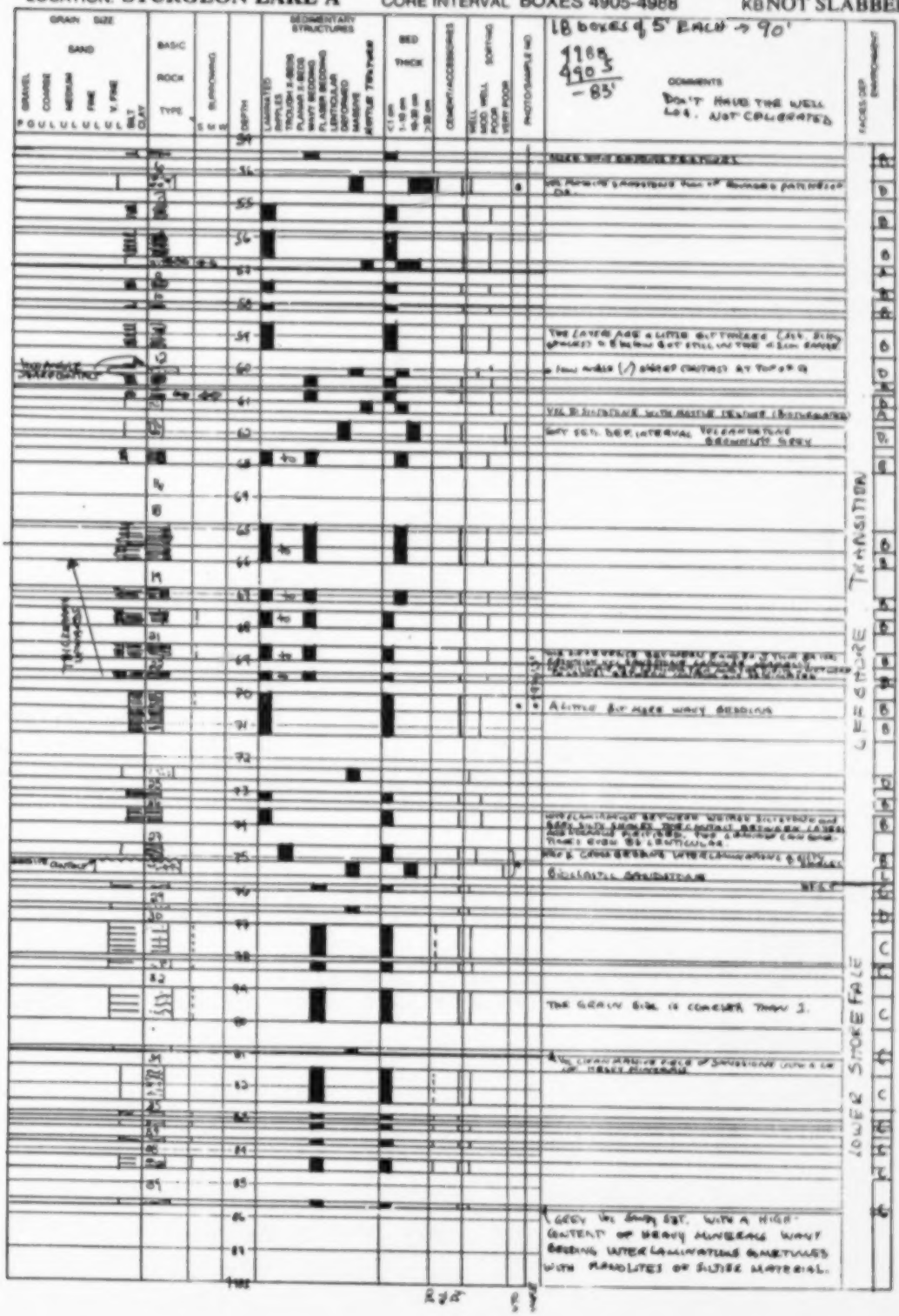
WELL NAME: 5-12-69-22W5 (2 OF 2) FORMATION: MONTNEY DATE: AUG. 24, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4900-4959 KB: NOT SLABBED



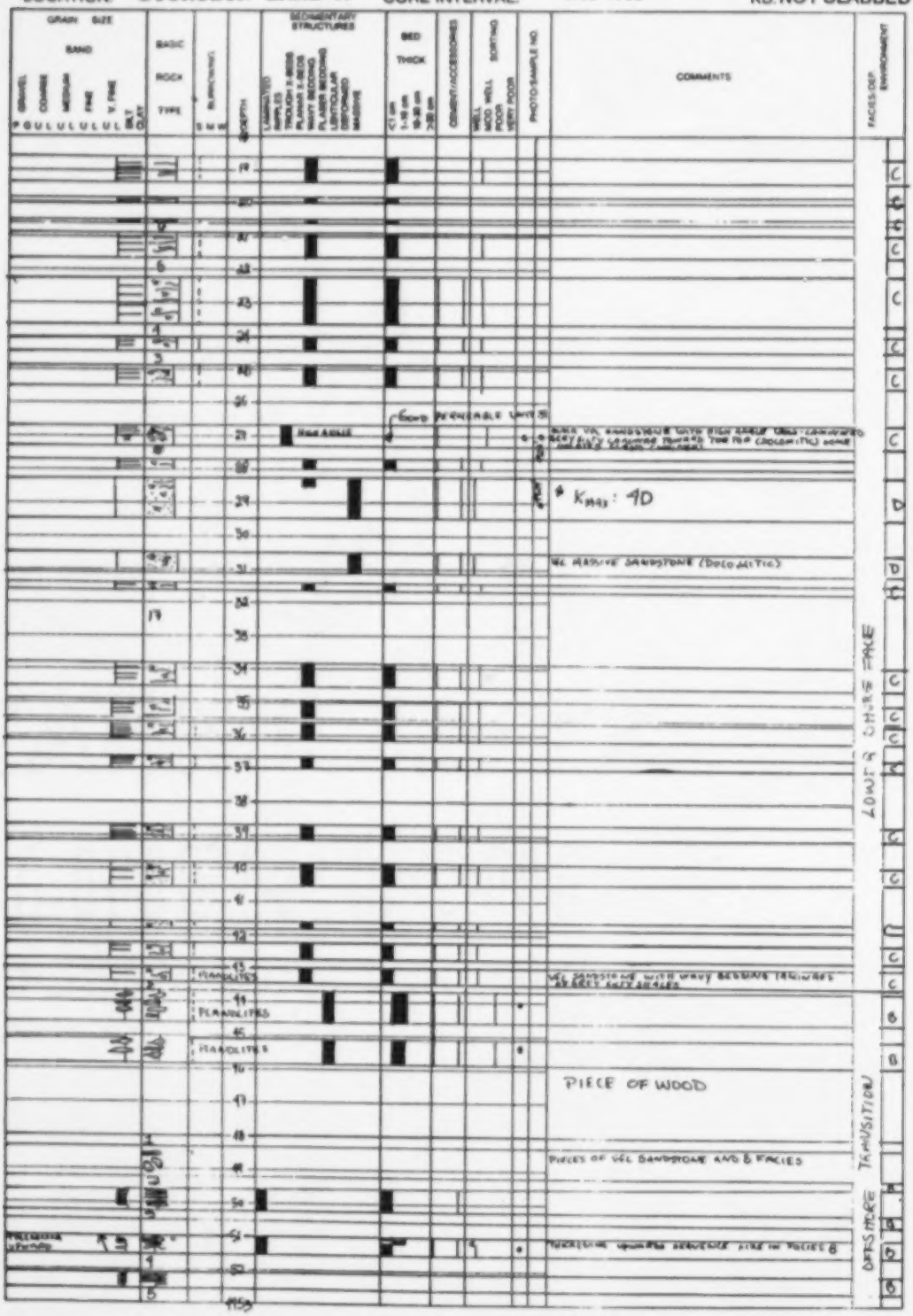
WELL NAME: 9-12-69-22W5 (1 OF 3) FORMATION: MONTNEY DATE AUG. 25, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL BOXES 4905-4988 KB NOT SLABBED



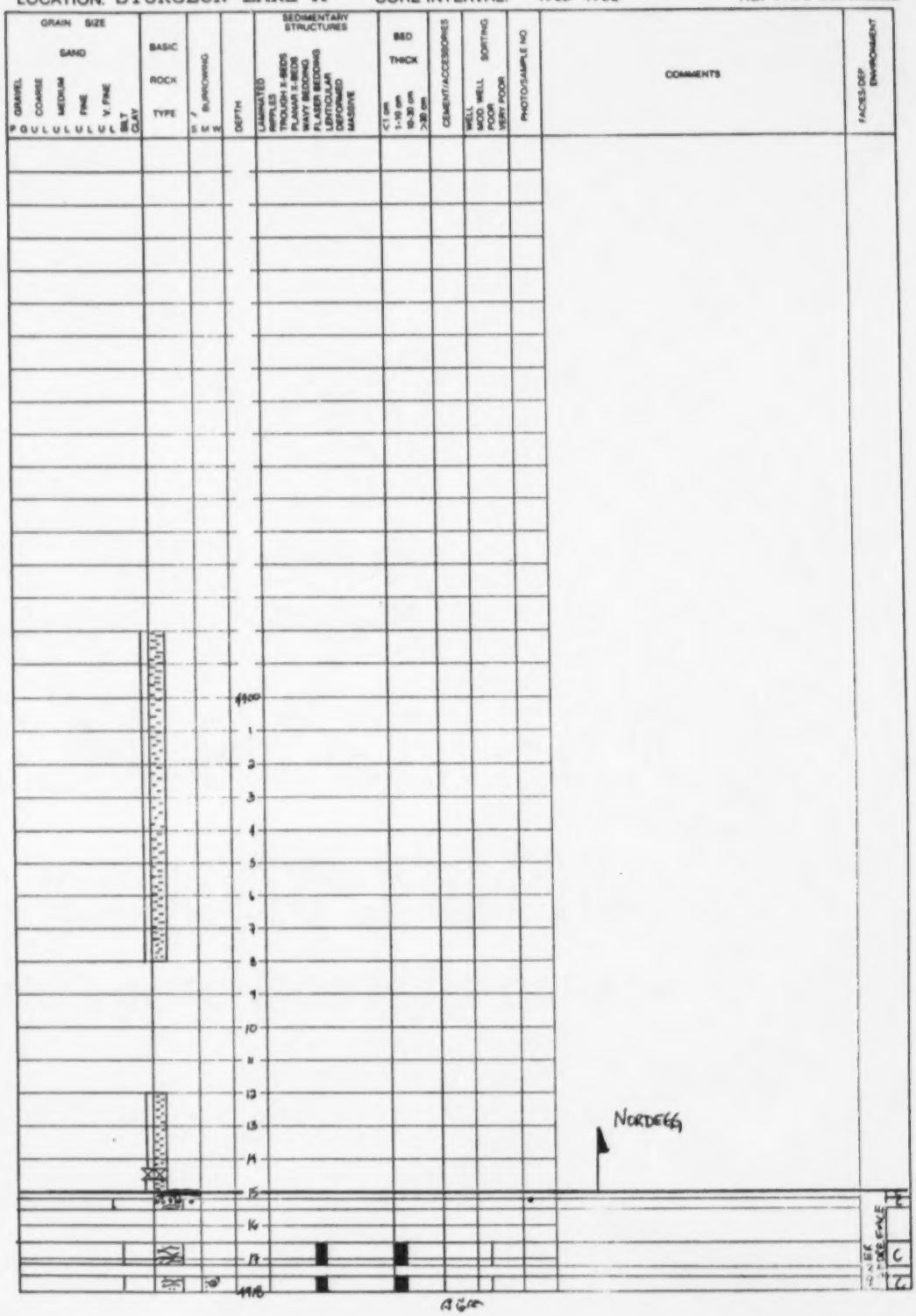
WELL NAME 9-12-69-22W5 (2 OF 3) FORMATION: MONTNEY DATE AUG. 25, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4905-4988 KB: NOT SLABBED



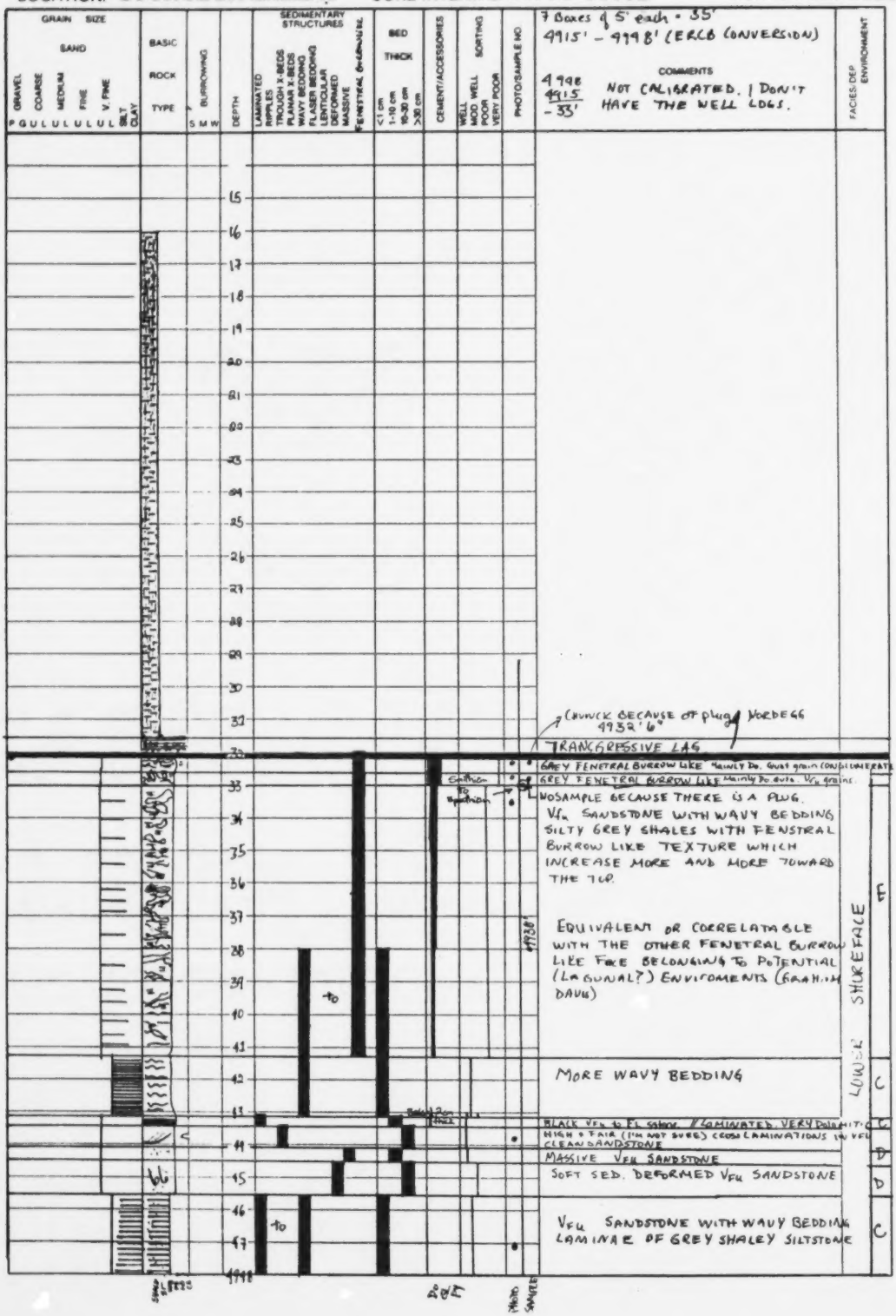
WELL NAME: 09-12-69-22W5 (3 OF 3) FORMATION: MONTNEY DATE: AUG. 25, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 4905'-4988' KB: NOT SLABBED



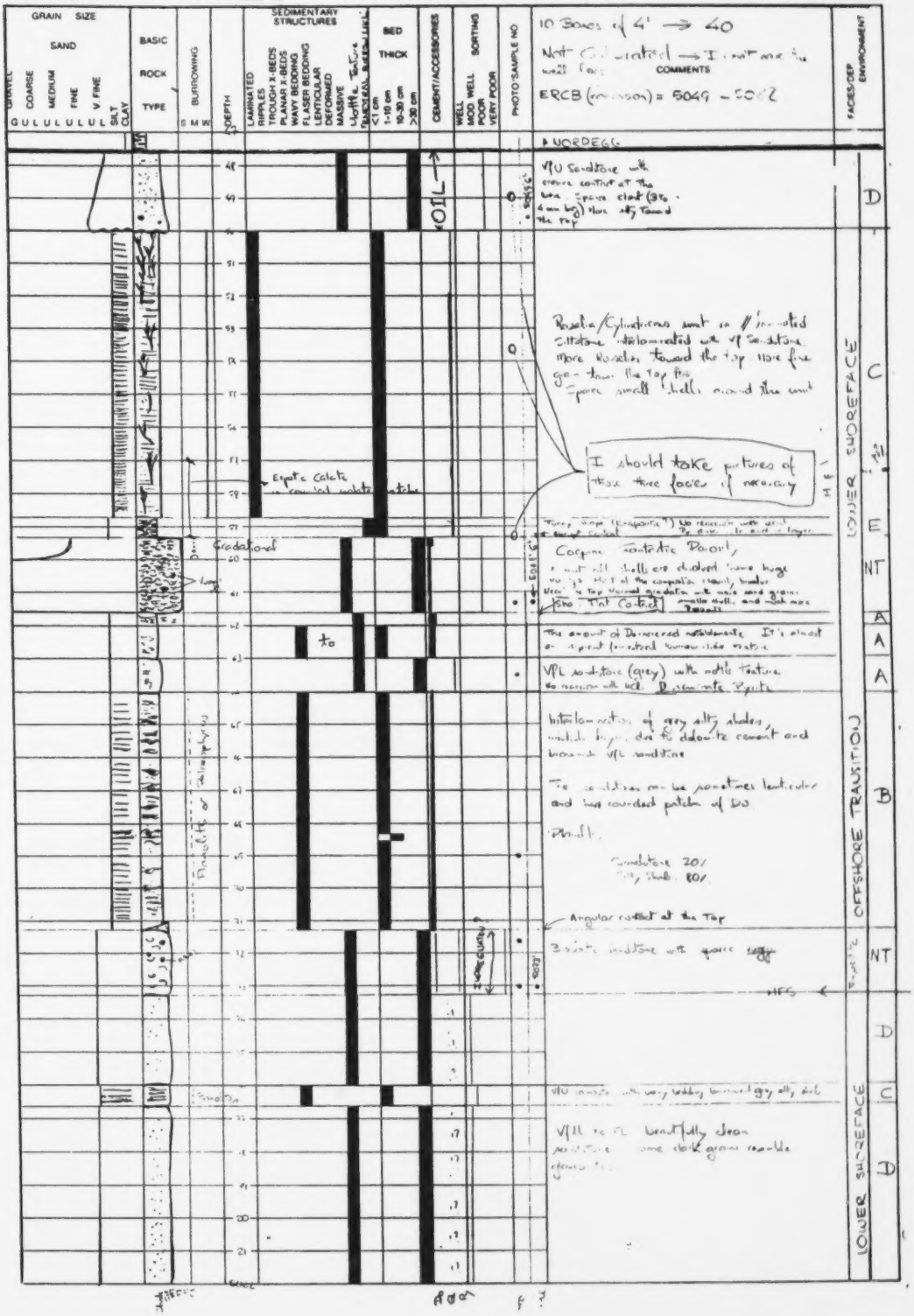
WELL NAME: 11-12-69-22W5 (1 OF 1) FORMATION: MONTNEY DATE AUG. 28, 1993

LOCATION: **STURGEON LAKE A** CORE INTERVAL: 1495m - 1500m KB: NOT SLABBED


7 Boxes @ 5' each = 35'
4915' - 4998' (ERCB CONVERSION)
4998
4915
-33'
NOT CALIBRATED. I DON'T HAVE THE WELL LOGS.
(CHUNCK BECAUSE OF plug 4932'6" WORDEGG
TRANSGRESSIVE LAG
GREY FENETRAL BURROW LIKE
GREY FENETRAL BURROW LIKE
NO SAMPLE BECAUSE THERE IS A PLUG.
Vf. SANDSTONE WITH WAVY BEDDING SILTY GREY SHALES WITH FENSTRAL BURROW LIKE TEXTURE WHICH INCREASE MORE AND MORE TOWARD THE TOP.
EQUIVALENT OR CORRELATABLE WITH THE OTHER FENETRAL BURROW LIKE FACE BELONGING TO POTENTIAL (LAGUNAL?) ENVIROMENTS (GRAHAM DAVIS)
MORE WAVY BEDDING
MASSIVE VFL SANDSTONE
SOFT SED. DEFORMED VFL SANDSTONE
VFL SANDSTONE WITH WAVY BEDDING LAMINAE OF GREY SHALEY SILTSTONE
LOWER SHOREFACE

WELL NAME: 6-27-69-22W5 (1 OF 1) FORMATION MONTNEY DATE: AUG. 28, 1993

LOCATION: STURGEON LAKE A CORE INTERVAL: 1539-1549 KB: NOT SLABBED



APPENDIX B

Appendix B contains petrographical descriptions from the samples taken from the Montney cores in the study area.

STURGEON LAKE B
WELL: 6-11-68-21W5 (1 OF 1)
DEPTH: 5224'5"
MICROFACIES 7: FACIES E

TEXTURAL CLASSIFICATION AND MINERALOGY	HYBRID SANDSTONE (BURROWED) MOTTLED TEXTURE QUARTZ PLAGIOCLASE PYRITE 2% HEAVY MINERALS
MATRIX	40% OF MICRITE IRREGULARLY DISTRIBUTED
POROSITY	0%
DOLOMITE	25% MAINLY ROUNDED CRYSTALS (DETRITIC? REPLACEMENT?). CRYSTALS SIZE 3-10 UNITS (10x) SEEMS THAT THE DOLOMITE IS DETRITIC
QUARTZ	BAD TO MODERATELY SORTED, SUBROUNDED TO ANGULAR, GRAIN SIZE: 2-12 UNITS, AVERAGE 5 UNITS (10x) COARSE SILT CALCITE EATING QUARTZ

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 6-11-68-21W5 (1 OF 1)
DEPTH: 5237'
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	60% HYBRID SANDSTONES 40% OF QUARTZ ARENITES (INTERLAMINATED)
POROSITY	7% PRIMARY (INTERPARTICLE) IN THE QUARTZ ARENITE
MATRIX	50% ARGILLACEOUS AND DOLOMITIC. IT IS DISTRIBUTED WITHIN THE HYBRID SANDSTONES
MINERALOGY	QUARTZ 44% FR. OF METAMORPHIC ROCKS (SLATES) 1% PLAGIOCLASE 1% TOURMALINE 2% ZIRCON MUSCOVITE PYRITE
DOLOMITE	AS CRYSTALS (5 TO 12 UNITS IN 10x) (MAINLY SMALL): VOID FILLING PATCHES (SPAR DOLOMITE) :CEMENT - TOTAL OF 5%
COMMENTS	THE MATRIX IN THE HYBRID SANDSTONES OF THIS SAMPLE IS MORE CARBONATE THAN THE AVERAGE. IT IS ALSO TOTALLY DOLOMITIZED AND IT HAS SOME CLAY CONTENTS. FOR THE HYBRID SANDSTONE'S, THE SORTING IS MODERATE. FOR THE QUARTZ ARENITE, THE SORTING IS GOOD. THE QUARTZ GRAINS ARE ANGULAR TO SUBROUNDED, 5 TO 30 UNITS IN 40x -> 0.01 TO 0.075MM WHICH CORRESPOND TO A MEDIUM SILT TO VERY FINE SAND.

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 15-18-68-21W5 (1 of 1)
FORMATION: MONTNEY
DEPTH: 5131'6"
MICROFACIES 1 FACIES WPB

LITHOLOGY	DOLOMITE
TEXTURAL CLASSIFICATION	DOLOWACKESTONE
FABRIC	MOLDS OF BIVALVES AND/OR BRACHIOPODS 15% LINGULA FRAGMENTS 2% GASTROPODS 1%
MINERALOGY	DOLOMITE 91% QUARTZ 7% PHOSPHATES (LINGULA FRAGMENTS)2%
POROSITY	15% MOLDIC (DISSOLUTION OF SHELLS) 20% 5% VUGGY
SHELLS	MODERATELY WELL SORTED WITH CERTAIN ORIENTATION: MOST OF THE CASES FACING UPWARD ( ) AVERAGE SIZE: 2mm MAXIMUM SIZE: 7mm
QUARTZ	MODERATELY TO WELL SORTED, SUBANGULAR TO SUBROUNDED. AVERAGE SIZE 0.1mm (12 UNITS 10x) EQUIVALENT TO VERY FINE SAND
DOLOMITE	A) REPLACEMENT: ANHEDRAL TO SUBHEDRAL, CLOUDY YELLOWISH, DIRTY APPEARANCE. REPLACEMENT OF THE MICRITIC MATRIX. SMALL (10 UNITS IN 20x) B) VOID FILLING EUHEDRAL, DISTRIBUTED AROUND MOLDS SMALL TO MEDIUM SIZE
DIAGENETIC PROCESSES	REPLACEMENT DISSOLUTION OF SHELLS CEMENTATION?

STURGEON LAKE B
WELL: 15-18-68-21W5 (1 OF 1)
DEPTH: 5144'2"
MICROFACIES 5B: FACIES C

RESIDUAL OIL	25% OF THE POROSITY, CONCENTRATED IN THE UPPER PART OF THE SECTION
MINERALOGY	QUARTZ TOURMALINE ZIRCON GLAUCONITE PLAGIOCLASE CHERT 2% METAMORPHIC FRAGMENTS 1% MICROCLINE DOLOMITE (REPLACING SHELLS)
POROSITY	35% PRIMARY (INTERPARTICLE)
VOID FILLING	7% OF EUHEDRAL, CLOUDY. 7 UNITS IN 10x (SMALL)) DOLOMITE
MATRIX	15% IRREGULARLY DISTRIBUTED, DOLOMITIC (SUBHEDRAL, SMALL) THERE IS NOT ARGILLACEOUS MATERIAL
GRAINS	MODERATELY TO WELL SORTED ANGULAR TO SUBROUNDED GRAINS LONGITUDINAL, TANGENTIAL CONTACTS, GRAIN/MATRIX 4 TO 20 UNITS IN 10x VERY FINE SANDSTONE

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B POOL
WELL: 5-19-68-21W5 (1 of 2)
DEPTH: 5080'2"
MICROFACIES 3 -> CONTACT BETWEEN FACIES DM AND FACIES WPB

LITHOLOGY	DOLOMITE
TEXTURAL CLASSIFICATION	DOLOWACKESTONE WITH A BIG FRAGMENT OF A DOLOMUDSTONE. NATURE OF THE CONTACTS BETWEEN THE TWO FACIES: VERY SHARP AND PYRITIZED. IN SOME PARTS THERE IS MICROPOROSITY ALONG THE CONTACT AND TOWARD THE MUDSTONE (SEE '*' IN THE ABOVE DIAGRAM)
DOLOWACKESTONE	A) MINERALOGY: 94% Do., 5% PHOSPHATES, 1% QUARTZ B) POROSITY: 22% (15% MOLDIC POROSITY. RESIDUAL OIL IN THE NECKS OF THE PORES (OCCASIONALLY IN THE WHOLE PORE), 7% VUGGY POROSITY) C) FABRIC: SHELLS (CURRENTLY MOLDS) BRACHIOPODS AND/OR BIVALVES? MOLDS 15% LINGULA cf. FRAGMENTS 5% ARENACEOUS FORAMS? LESS THAN 1% PELOIDS LESS THAN 1% D) DOLOMITE: A) REPLACEMENT: SMALL TO MEDIUM SIZE (80um to 120um), SUBHEDRAL, CLOUDY B) VOID FILLING: 2%, EUHEDRAL, SMALL TO MEDIUM SIZE, OVERGROWTH OF Do (MANY CEMENTATION EVENTS?)
DOLOMUDSTONE FRAGMENT	EVIDENCES TO ASSUME THAT IT IS A FRAGMENT: - BORINGS - IRREGULAR CONTACTS - LOCATION (COARSER PART OF WPB)

STURGEON LAKE B POOL
WELL: 5-19-68-21W5 (2 OF 2)
FORMATION: MONTNEY
DEPTH: 5080'2"
MICROFACIES 3 -> CONTACT BETWEEN FACIES DM AND FACIES WPB

CONTINUATION OF DOLOMUDSTONE FRAGMENTS:

MINERALOGY	Do 95% Qz 5% PHOSPHATE LESS THAN 1% (SOME LINGULA FRAGMENTS)
QUARTZ	IT HAS BEEN EATEN BY Do. SILT. (0.024mm-0.06mm) SUBROUNDED TO SUBANGULAR FRAGMENTS
DOLOMITE	REPLACEMENT OF THE MATRIX ANHEDRAL CRYSTALS OF SMALL SIZE (<100um)
DIAGENETIC PROCESSES	DISSOLUTION OF SHELLS (MOLDIC) REPLACEMENT INCIPIENT CEMENTATION ? OIL MIGRATION OR ACCUMULATION

MAGNIFICATION IN THE MICROSCOPE: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20X = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 5-19-68-21W5 (1 OF 1)
DEPTH: 5088'
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	35% LAMINAE OF HYBRID SANDSTONES 65% LAMINAE OF QUARTZARENITES (INTERLAMINATED)
MATRIX	15% ARGILLACEOUS AND DOLOMITE
MINERALOGY	QUARTZ 45% CHERT 2% PLAGIOCLASE 1% MUSCOVITE 1% GLAUCONITE LESS THAN 1% MICROCLINE LESS THAN 1% ZIRCON LESS THAN 1%
POROSITY	25% PRIMARY (INTERPARTICLE) IN THE LAMINAE OF QUARTZARENITES
QUARTZ	WELL SORTED TO MODERATELY SORTED. SUBANGULAR TO SUBROUNDED GRAINS. SIZE: 5 TO 10 UNITS IN 10x -> 0.05 TO 0.1 (VERY FINE SAND)
VOID FILLING	10% OF SMALL (5 UNITS IN 10x) CRYSTALS DOLOMITE

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 11-19-68-21W5
DEPTH: 5095'3"
MICROFACIES 5B: FACIES C

MINERALOGY	QUARTZ ZIRCON TOURMALINE CHERT METAMORPHIC FR. PLAGIOCLASE MUSCOVITE
POROSITY	10% PRIMARY (INTERPARTICLE)
VOID FILLING	2% CRYSTALS OF DO (6 TO 11 UNITS IN 10x) (SMALL)
MATRIX	50%DOLOMITIC (REPLACEMENT) THE MATRIX IS NOT SO ARGILACEOUS. THE Do CRYSTAL FOR THE SAMPLE ARE BIGGER AND BETTER DEVELOPED THAN AN AVERAGE SAMPLE.
GRAINS	CONTACTS: GRAIN/MATRIX, LONGITUDINAL AND TANGENTIAL MODERATELY SORTED, SUBANGULAR TO SUBROUNDED GRAINS (4 TO 12 UNITS IN 10x) (COARSE SILT TO VERY FINE SANDSTONE)

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 7-26-68-21W5 (1 OF 1) MARGINAL SIDE OF THE POOL (DRY WELL)
DEPTH: 5231'9"
MICROFACIES 5: FACIES C

GENERAL DESCRIPTION	VERY CLEAN WHITE OR LIGHT GREY VERY FINE UPPER SANDSTONE. SOME GLAUCONITE GRAINS. WAVY BEDDING LAMINAE OF SILTSTONE MIXED WITH CARBONACEOUS MATERIAL AND A LOT OF MUSCOVITE GRAINS. THIS UNIT IS CLEANER THAN THE NORMAL FACIES C.
MICROFACIES	IN THIS CASE THE LAMINAE OF HYBRID SANDSTONES ARE LESS AND THINNER THAN AVERAGE. THE QUARTZ GRAIN SIZE IS ALSO BIGGER
MINERALOGY	QUARTZ 63% CHERT 2% TOURMALINE 1% LESS THAN 1% OF: PYRITE, ZIRCON, GLAUCONITE,PLAGIOCLASE,METAMORPHIC FR, MICROCLINE, MUSCOVITE
MATRIX	6% -> OF CALCITE (NOW REPLACED BY Do) AND CLAYS
POROSITY	20% PRIMARY (INTERPARTICLE)
CEMENT	QUARTZ OVERGROWTH 1%
VOID FILLING	7% OF EUHEDRAL RHOMBO, CLOUDY, CRYSTAL SIZE (AVERAGE 7 TO 12 UNITS IN 10x) SMALL TO MEDIUM
COMMENTS	SORTING: WELL TO MODERATE SUBROUNDED GRAINS STRAIGHT CONTACTS BETWEEN GRAINS AVERAGE GRAIN SIZE: 7 UNITS IN 10x 0.07mm VERY FINE SANDSTONE RANGE IN GRAIN SIZE: 5 TO 20 UNITS IN 10x COARSE SILT TO FINE SANDSTONE

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 5-32-68-21W5 (1 OF 1) -> NEAR THE BORDER OF STURGEON LAKE A
DEPTH: 4991'6"
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	55% OF QUARTZ ARENITES 45% OF HYBRID SANDSTONES (INTERLAMINATED)
MINERALOGY	QUARTZ 47% CHERT 2% METAMORPHIC FR. 1% TOURMALINE ZIRCON MUSCOVITE PLAGIOCLASE MICROCLINE GLAUCONITE PYRITE
MATRIX	25% DOLOMITE AND ARGILLACEOUS
CEMENT	1% OF QUARTZ OVERGROWTH 3% OF PATCHES OF SPAR OF Do.
VOID FILLING	5% OF EUHEDRAL, CLOUDY, SMALL TO MEDIUM (7 TO 15 UNITS IN 10x) Do.
POROSITY	15% PRIMARY (INTERPARTICLE) DISTRIBUTED IN THE QUARTZ ARENITES
COMMENTS	SORTING IS MODERATE CONTACTS: STRAIGHT, PUNTUALS , GRAIN/MATRIX SUBANGULAR TO SUBROUNDED GRAINS GRAINS SIZE: 3 TO 15 UNITS IN 10x

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 13-36-68-21W5 (1 OF 1)
DEPTH: 5063'6"
MICROFACIES 5B: FACIES C
MICROFACIES 5B: MICROFACIES 5 BUT BIOTURBATED -> QUARTZ WACKE/ HYBRID SANDSTONE

MINERALOGY	QUARTZ MUSCOVITE PLAGIOCLASE ZIRCON MICROCLINE CHERT 1% PYRITE
MATRIX	50%
POROSITY	20%
VOID FILLING	5% OF DOLOMITE: EUHEDRAL, CLOUDY (7 TO 12 UNITS IN 10x) (SMALL TO MEDIUM)
GRAINS	ROUNDED TO SUBROUNDED GRAINS MODERATELY SORTED CONTACTS: LONGITUDINAL GRAIN/MATRIX RANGE OF GRAIN SIZE: 3 TO 12 UNITS IN 10x COARSE SILT TO VERY FINE SANDSTONE

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 14-10-68-22W5 (1 OF 1)
DEPTH: 5268'
MICROFACIES 3: CONTACT BETWEEN FACIES WPB AND FACIES DM

CONTACT	SHARP, STYLOLITIC. UNDER THE MICROSCOPE CAN BE SEEN SOME SORT OF GRADATION
DOLOMUDSTONE	LAMINATED MINERALOGY: DOLOMITE 95% (ANHEDRAL TO SUBHEDRAL CLOUDY 30um (SMALL Do)) OPAQUE MINERALS 4% QUARTZ 1%
DOLOWACKESTONE	FABRIC: INTRACLASTS 3% SHELLS (LAMINAE OF Ca, LAMINAE OF Do) 4% CEMENTS: GLAUCONITE LESS THAN 1% QUARTZ AND/OR GYPSUM 20% POROSITY: 12% OF VUGGY AND INTERACRYSTALLINE MINERALOGY: DOLOMITE 89% (EUHEDRAL, OCCASIONALLY SUBHEDRAL NOT SO CLOUDY)- 40 TO 120um (SMALL TO MEDIUM) REPLACEMENT, SUCROSIC Do PHOSPHATE 4% PY 7%

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 7-23-68-22W5 (1 OF 2)
FORMATION: MONTNEY
DEPTH: 5110'6"
MIRCOFACIES 1 -> FACIES WPB

LITHOLOGY	DOLOMITE
TEXTURAL CLASSIFICATION	WACKESTONE
FABRIC	CONCORDANT (KINDWELL,) SHELLS OF BIVALVES AND/OR BRACHIOPODS (15%), cf. LINGULA FRAGMENTS (1%), ARENACEOUS FORAMS
MINERALOGY	DOLOMITE 97% QUARTZ 2% PHOSPHATE 1%
POROSITY	15% MOLDIC 20% 5% VUGGY 1% VERTICAL FRACTURES
QUARTZ	A) MODERATELY SORTED SUBROUNDED TO SUBANGULAR, RANDOMLY DISTRIBUTED. GRAIN SIZE: VERY FINE TO MEDIUM SAND B) SILICIFIED SHELLS (RELICS OF DOLOMITE (RARE) (GHOSTS?))
SHELLS	CONCORDANT SHELLS, MODERATELY SORTED, 1mm-1cm WITH AN AVERAGE SIZE OF 6mm.
DOLOMITE	A) REPLACEMENT: ANHEDRAL, SOMETIMES SUBHEDRAL YELLOWISH-DIRTY CLOUDY DOLOMITE SIZE: MEDIUM 71% B) VOID FILLING: EUHEDRAL, LESS CLOUDY (CLEANER). MEDIUM SIZE, ABUNDANCE 5%

STURGEON LAKE A
WELL: 7-23-68-22W5 (2 OF 2)
FORMATION: MONTNEY
DEPTH: 5110'6"
MICROFACIES 1: FACIES WPB

DIAGENETIC PROCESSES	-DISSOLUTION OF SHELLS -REPLACEMENT -CEMENTATION OF DO IN THE RIM OF THE DISSOLVED SHELLS (OR IT IS JUST REPLACEMENT AT THE BORDERS OF THE PORES) -SILICIFICATION

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 3-24-68-22W5 (1 OF 1)
DEPTH: 5167'2" = 5268 (IN THE CORE)
MICROFACIES 3: CONTACT BETWEEN FACIES WPB AND FACIES DM

CONTACT	SHARP AND VERY IRREGULAR CONTACT (EROSIVE?)
DOLOWACKESTONE	FABRIC: PELOIDS (MICRITIC GRAINS) (SOME SEEMS TO BE: ALGAE) 4% FORAMS 1% LINGULAS 4% BRACHIOPOD MOLDS 1% GHOSTS OF BRACHIOPODS 10% (NOW DOLOMITIZED, PERVASIVE Do) POROSITY: 1% MOLDIC 7% 6% VUGGY VERY LITTLE OIL REMAINS IN SOME PORES MINERALOGY: DOLOMITE 93% MICRITE 4% PHOSPHATE 2% QUARTZ 1% (COARSE SILT, ROUNDED TO SUBROUNDED, IT HAS BEEN EATEN BY Do DOLOMITE, REPLACEMENT, SUBHEDRAL, CLOUDY, VOID FILLING, CLEAN, EUHEDRAL Do, SMALL DISTRIBUTED IN THE RIMS OF THE PORES 4%
DOLOMUDSTONE	MINERALOGY: DOLOMITE 95% QUARTZ 5% POROSITY: LESS THAN 1% (OPEN FRACTURES) DOLOMITE-> REPLACEMENT CLOUDY, ANHEDRAL AND VERY SMALL QUARTZ SILT (MEDIUM TO COARSE), SUBANGULAR TO SUBROUNDED, IT HAS BEEN EATEN BY Do.

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8m
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 9-24-68-21W5 (1 OF 1)
DEPTH: 5103'2"
MICROFACIES 4: WPB

DOLOWACKESTONE/PACKSTONE OF LINGULA FRAGMENTS, AND COATED GRAINS	FABRIC: LINGULA FRAGMENTS AND OTHER SHELLS 30% COATED GRAINS 25% (DISTRIBUTED AS AN INTERLAMINATION OF ALTERNATING TYPES OF FABRIC) LARGE INTRACLASTS 10% PELOIDS 2% POROSITY: 1% OF FRACTURE, 1 TO 2% OF INCIPIENT MOLDIC POROSITY MINERALOGY: DOLOMITE PHOSPHATES MICRITE QUARTZ PYRITE THE QUARTZ IS RANDOMLY DISTRIBUTED AND IT IS CONCENTRATED IN PATCHES. IT IS SUBANGULAR TO SUBROUNDED (10 TO 40 UNITS IN 40x)
DIAGENETIC PROCESSES	REPLACEMENT
COMMENTS	

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 13-24-68-22W5 (1 OF 1)
DEPTH: 5069'3"
MICROFACIES 3: CONTACT BETWEEN FACIES WPB AND FACIES DM

COMMENT	IN THE CORE THE CONTACT IS BETWEEN A PACKSTONE (DOWN) AND A WACKESTONE (UP). IN THE THIN SECTION WHAT ONE SEE IS A CONTACT BETWEEN A MUDSTONE (DOWN) AND A MUDSTONE/WACKESTONE (UP)
DOLOMUDSTONE-WACKESTONE	FABRIC: 3% OF PHOSPHATE AND GLAUCONITIC GRAINS, MICRITIC GRAINS AND LINGULA cf. FRAGMENTS 10% OF MOLDS OF BRACHIOPODS AND/OR BIVALVES AND DOLOMITIZED BRACHIOPODS AND/OR BIVALVES POROSITY: 25% INTERCRYSTALLINE AND MOLDIC MINERALOGY: DOLOMITE 76% PHOSPHATE 3% GLAUCONITE LESS THAN 1% QUARTZ 20% DOLOMITE: REPLACEMENT SMALL, CLOUDY, EUHEDRAL TO SUBHEDRAL QUARTZ: Vf SAND GRAINS, SUBROUNDED TO SUBANGULAR
DOLOMUDSTONE	97% OF ANHEDRAL, CLOUDY, SMALL Do (REPLACEMENT) 3% OF QUARTZ 7% OF INTERCRYSTALLINE POROSITY
DIAGENETIC PROCESSES	DISSOLUTION REPLACEMENT GLAUCONIZATION

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 7-27-68-22W5 (1 OF 1)
DEPTH: 5135'8"
MICROFACIES 1: FACIES WPB

LITHOLOGY	DOLOMITE
TEXTURAL CLASSIFICATION	WACKESTONE
FABRIC	PELOIDS 10% LINGULA FRAGMENTS 4% BRACHIOPODS AND/OR BIVALVES MOLDS 3% ARENACEOUS FORAMS LESS THAN 1%
MINERALOGY	DOLOMITE 76% MICRITE 10% PHOSPHATE 4% QUARTZ 10%
POROSITY	3% MOLDIC 7% 4% VUGGY SOME PORES ARE FILLED WITH OIL
DOLOMITE	REPLACEMENT: ANHEDRAL, SMALL CLOUDY Do VOID FILLING: EUHEDRAL, SOMETIMES SUBHEDRAL, SMALL TO MEDIUM SIZE. DISTRIBUTED AT THE RIMS OF THE MOLDS 3%
QUARTZ	WELL SORTED TO MODERATELY SORTED SUBANGULAR TO SUBROUNDED IT HAS BEEN EATEN BY Do SIZE: 20 UNITS IN 20x VERY FINE SAND
OTHER TYPES OF CEMENT	SPAR Ca (LESS THAN 1%) (Do CRYSTAL WITHIN THIS CEMENT)
COMMENTS	ORGANIC STRUCTURE WITH BORINGS

MAGNIFICATION IN THE MICROSCOPE: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS =0.4mm

STURGEON LAKE A
WELL: 7-4-69-21W5 (1 OF 1)
DEPTH: 4963'
MICROFACIES 5: FACIES C

COMMENTS	INTERLAMINATION OF QUARTZ ARENITE AND HYBRID SANDSTONES. THE LAMINAE ARE IRREGULAR WITH AN APPROXIMATED THICKNESS OF 0.2mm -40% HYBRID SANDSTONES -60% QUARTZ ARENITES THE HYBRID SANDSTONE'S ARE CONSTITUTED BY FINE QUARTZ GRAINS SURROUNDED BY A SILICLASTIC AND A CARBONATE MATRIX. THE CARBONATE MATRIX IS REPLACED BY DOLOMITE
MATRIX	MATRIX 22%
MINERALOGY	QUARTZ 50% PLAGIOCLASE 2% CHERT 1% MUSCOVITE LESS THAN 1% TOURMALINE LESS THAN 1% ZIRCON LESS THAN 1% GLAUCONITE LESS THAN 1%
POROSITY	155 PRIMARY (INTERPARTICLE). JUST IN THE LAMINAE OF QUARTZ ARENITES
QUARTZ	5 TO 20 UNITS IN 10x -> 0.05 TO 0.2mm (COARSE SILT TO FINE SAND) AVERAGE GRAIN SIZE 10 UNITS IN 10x -> 0.1mm (VERY FINE SAND) ANGULAR TO SUBANGULAR GRAINS WELL SORTED IN THE QUARTZ ARENITES MODERATELY SORTED IN THE HYBRID SANDSTONE
DOLOMITE	VOID FILLING AS CRYSTALS 10% (10 UNITS IN 10x: SIZE OF THE CRYSTALS) CEMENT AS PATCHES OF SPAR Do

MICROSCOPE MAGNIFICATION: 3.2x= 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 13-4-69-21W5 (1 OF 1)
DEPTH: 4943'
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	70% OF QUARTZ ARENITES 30% OF HYBRID SANDSTONE (INTERLAMINATED)
COMMENTS	BURROW WITH NO LINING (PLANOLITES cf.)
MINERALOGY	QUARTZ 98% METAMORPHIC 1% MUSCOVITE 1% LESS THAN 1% OF: TOURMALINE PLAGIOCLASE ZIRCON CHERT
MATRIX	20%
POROSITY	20% PRIMARY (INTERPARTICLE)
BEST Kmax VALUE	20md AT 4941'
GRAINS	MODERATELY SORTED CONTACTS: TANGENTIAL, LONGITUDINAL, GRAIN/MATRIX, GRAIN/CEMENT ANGULAR TO SUBROUNDED GRAINS GRAIN SIZE: 4 TO 10 UNITS IN 10x (4 UNITS AVERAGE) -> COARSE SILTSTONE
CEMENT	7% PATCHES OF SPAR DOLOMITE
VOID FILLING	7% EUHEDRAL, CLOUDY, SMALL (>100um (7UNITS IN 10x)) DOLOMITE

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 15-4-69-21W5 (1 OF 1)
DEPTH: 4838'????
MICROFACIES 3: CONTACT BETWEEN FACIES WPB AND M

CONTACT	CONCENTRATION OF THE SHELLS IN CONCORDANT POSITION, INTRACLASTS (MICRITIC GRAINS AT THE BASE OF THE WACKESTONE IT IS ALSO CEMENT OF GLAUCONITE AT THAT LEVEL
DOLOWACKESTONE	MINERALOGY AND CONSTITUENTS: -DOLOMITE 95% -PHOSPHATES 4% -GYPSUM AND/OR QUARTZ 7% CEMENT -INTRACLASTS 1% -QUARTZ 1% -GI LESS THAN 1% POROSITY: 17% VUGGY RESIDUAL OIL DOLOMITE: BANDS OF DIFFERENT SIZE, THE BANDS OF BIGGER SIZE THE DOLOMITE IS SUBHEDRAL TO EUHEDRAL, RELATIVELY CLEAN, ASSOCIATED WITH VUGGY . MEDIUM SIZE (120 TO 210um). THE BANDS WITH THE SMALLER SIZE OF Do. THE Do IS MORE COMPACTED AND IT HAS SUBHEDRAL SHAPE. IN GENERAL IS CLOUDIER. SMALL(30 TO 100um) THERE IS ALSO Do AS VOID FILLING
DOLOMUDSTONE	97% OF ANHEDRAL SMALL CLOUDY Do AND 3% OF QUARTZ
COMMENTS	WHAT IT IS NOTORIOUS ABOUT THIS SAMPLE IS: A) CONCENTRATION OF SHELLS AND INTRACLASTS AT THE CONTACT B) GYPSUM CEMENT

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 7-5-69-21W5 (1 OF 1)
DEPTH: 4943'6"
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	55% OF QUARTZ ARENITES 45% OF HYBRID SANDSTONE (INTERLAMINATED)
MINERALOGY	QUARTZ 44% CHERT 1% LESS THAN 1% OF: PYRITE, MUSCOVITE, PLAGIOCLASE, ZIRCON, TOURMALINE, GLAUCONITE
MATRIX	MIXTURE OF CARBONATES (Do) AND ARGILACEOUS MATRIX 30%
POROSITY	15% PRIMARY (INTERPARTICLE)
CEMENTS	PATCHES OF Do (SPAR) 3%
VOID FILLING	EUHEDRAL CLOUDY CRYSTALS OF Do. 7% AVERAGE SIZE OF THE CRYSTALS: 7 UNITS IN 10x SMALL Do (>100um)
COMMENTS	SORTING WELL TO MODERATE GRAIN SIZE: 5 TO 10 UNITS IN 10x COARSE SILT TO VERY FINE SAND ANGULAR TO SUBROUNDED GRAINS STRAIGHT, PUNCTUAL, GRAIN/MATRIX, GRAIN/PORE CONTACTS

MICROSCOPE MAGNIFICATION: 3.2x =40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 7-5-69-21W5 (1 OF 1)
DEPTH: 4943'6"
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	55% OF QUARTZ ARENITES 45% OF HYBRID SANDSTONE (INTERLAMINATED)
MINERALOGY	QUARTZ 44% CHERT 1% LESS THAN 1% OF: PYRITE, MUSCOVITE, PLAGIOCLASE, ZIRCON, TOURMALINE, GLAUCONITE
MATRIX	MIXTURE OF CARBONATES (Do) AND ARGILACEOUS MATRIX 30%
POROSITY	15% PRIMARY (INTERPARTICLE)
CEMENTS	PATCHES OF Do (SPAR) 3%
VOID FILLING	EUHEDRAL CLOUDY CRYSTALS OF Do. 7% AVERAGE SIZE OF THE CRYSTALS: 7 UNITS IN 10x SMALL Do (>100um)
COMMENTS	SORTING WELL TO MODERATE GRAIN SIZE: 5 TO 10 UNITS IN 10x COARSE SILT TO VERY FINE SAND ANGULAR TO SUBROUNDED GRAINS STRAIGHT, PUNCTUAL, GRAIN/MATRIX, GRAIN/PORE CONTACTS

MICROSCOPE MAGNIFICATION: 3.2x =40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 9-6-69-21W5 (1 OF 1)
DEPTH: 4917'6"
MICROFACIES 5: FACIES C

TEXTURAL CLASSIFICATION	60% OF QUARTZ ARENITES 40% OF HYBRID SANDSTONES (INTERLAMINATED)
MINERALOGY	QUARTZ CHERT 3% METAMORPHIC FRAGMENTS 1% LESS THAN 1% OF: TOURMALINE, MICROCLINE, MUSCOVITE, ZIRCON, GLAUCONITE
MATRIX	25%
POROSITY	25% PRIMARY (INTERPARTICLE)
CEMENT	3% OF PATCHES OF Do
VOID FILLING	3% EUHEDRAL, CLOUDY, SMALL (7 UNITS OF 10x) DOLOMITE
COMMENTS	MODERATED SORTED CONTACTS: TANGENTIAL, LONGITUDINAL, GRAIN/MATRIX, GRAIN/CEMENT, ANGULAR TO SUBROUNDED GRAINS GRAIN SIZE: 5 TO 10 UNITS IN 10x COARSE SILT TO VERY FINE SAND

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 13-6-69-21W5 (1 OF 1)
DEPTH: 4899'5"
MICROFACIES 5A: FACIES C

TEXTURAL CLASSIFICATION AND GENERAL DESCRIPTION	INTERLAMINATION OF QUARTZWACKES/QUARTZ ARENITES AND HYBRID SANDSTONES. MICROFACIES 5A HAS MORE MATRIX THAN MICROFACIES 5. FOR THE HYBRID SANDSTONES, THE MATRIX IS DOLOMITE (REPLACEMENT OF Ca) AND ARGILLACEOUS. FOR THE QUARTZ WACKES/QUARTZ ARENITES, THE MATRIX IS A MIXTURE OF ORGANIC MATTER AND CLAYS. IN GENERAL THE FACIES IS MORE DOLOMITIC (VOID FILLING).
MINERALOGY	QUARTZ MUSCOVITE 1% CHERT 2% PLAGIOCLASE 1% TOURMALINE PYRITE ZIRCON
MATRIX	25%
CEMENT	2% PATCHES OF SPAR DOLOMITE
VOID FILLING	10% OF EUHEDRAL, CLOUDY, SMALL (AVERAGE 7 UNITS IN 10x) Do.
POROSITY	5% PRIMARY (INTERPARTICLE)
GRAINS	SUBANGULAR TO SUBROUNDED GRAINS SORTING: MODERATE GRAIN SIZE: (3 TO 11 UNITS IN 10x) COARSE SILT TO VERY FINE SANDSTONE CONTACTS: LONGITUDINAL, TANGENTIAL, GRAIN/MATRIX, GRAIN,CEMENT

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 9-7-69-21W5 (1 OF 1)
DEPTH: 4884'6"
MICROFACIES 6: FACIES D

MINERALOGY	DOLOMITE SANDSTONE QUARTZ 55% MUSCOVITE GHOST OF SHELLS NOW DOLOMITIZED 1% INTRACLASTS 1% GLAUCONITE GRAINS CHERT 3% METAMORPHIC FRAGMENTS PLAGIOCLASE TOURMALINE
POROSITY	20% PRIMARY (INTERPARTICLE) -> THIS SAMPLE IS IN THE **BEST PERMEABLE INTERVAL.**
CEMENT	10% PATCHES OF Do (SPAR)
VOID FILLING	10% CRYSTALS EUHEDRAL, SUBHEDRAL, CLOUDY. 4 TO 12 UNITS IN 10x (AVERAGE 8 UNITS) SMALL Do (100um)
GRAINS	WELL SORTED, SUBANGULAR TO SUBROUNDED GRAINS GRAIN SIZE: 3 TO 12 UNITS (AVERAGE 9 UNITS) VERY FINE SANDSTONE CONTACTS BETWEEN THE GRAINS: LONGITUDINAL AND TANGENTIAL

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 5-18-69-21W5 (1 OF 1)
DEPTH: 4904'6"
MICROFACIES 6: FACIES D

MINERALOGY	DOLOMITIC SANDSTONE QUARTZ MUSCOVITE CHERT 1% METAMORPHIC FRAGMENTS ZIRCON SHELLS (LINGULA) 3% MICRITIC GRAINS 1% ACCESSORIES: PLAGIOCLASE TOURMALINE MICROCLINE
POROSITY	5% PRIMARY (INTERPARTICLE)
CEMENT	LESS THAN 1% OF PATCHES OF Do (SPAR)
VOID FILLING	20% DOLOMITE CRYSTALS: EUHEDRAL, CLOUDY, HOMOGENEOUSLY DISTRIBUTED BETWEEN GRAINS, 5 TO 15 UNITS IN 10x SMALL TO MEDIUM
GRAINS	MODERATELY TO WELL SORTED CONTACTS: GRAIN/CEMENT, TANGENTIAL, LONGITUDINAL SUBANGULAR TO SUBROUNDED GRAINS GRAINS SIZE: 4 TO 12 UNITS IN 10x COARSE SILT TO vfs

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

WEST TO STURGEON LAKE A
WELL: 9-4-69-22W5 (1 of 2)
FORMATION: MONTNEY
DEPTH: 5156'3"
MICROFACIES 2 -> FACIES BR (BRECCIA)

POROSITY	1% OR LESS (VUGGY)
DESCRIPTION	ROUNDED TO SUBROUNDED FRAGMENTS POORLY SORTED FROM 1mm TO 3 cm (IN THE THIN SECTION) SURROUNDED BY A MICRITIC MATRIX A) MATRIX: DARK FAINTLY STAINED (SOME REMNANTS OF Ca.) DOLOMITIC MATRIX. VERY SMALL ANHEDRAL CRYSTAL (APHANITIC?). THIS FAINT DYE SUGGEST THAT IT'S A PARTIAL/ALMOST TOTAL REPLACEMENT OF Ca. BY Do. IN THE MATRIX. B) FRAGMENTS: THEY ARE CONSTITUTED MAINLY BY: - Do. (CRYSTALS RANGE FROM SMALL TO MEDIUM (40um to 120um) - 4% OF QUARTZ, MODERATELY SORTED, COARSE SILT- VERY FINE SANDSTONE (0.12-0.04) - 5% OF SHELLS: LINGULA cf, BRACHIOPODS AND BIVALVIA SILICIFICATION OF SOME SHELLS. QZT. GRAINS HAVE BEEN ATE BY Do.
COMMENTS	SHELLS DISTRIBUTED ALL OVER THE SAMPLE (FRAGMENTS AND MATRIX)(SUBMARINE BRECCIA?) WEIRD ALGAE LIKE FEATURES, PELOIDS IN SOME CASES THE CONTACTS BETWEEN THE FRAGMENTS AND THE MATRIX ARE STYLOLITIC SOME DOLOMITE CRYSTAL ARE SUBROUNDED, SUGGESTING SOME KIND OF TRANSPORT. THOSE ARE THE BIGGER CRYSTALS.

WEST TO STURGEON LAKE A
WELL: 9-4-69-22W5 (2 of 2)
FORMATION: MONTNEY
DEPTH: 5156'3"
MICROFACIES 2 -> FACIES BR (BRECCIA)

POSSIBLE ORIGIN OF THE DOLOMITE	1)FRAGMENTS AND 'DETRITAL DOLOMITE' SUGGEST THAT THE SOURCE WAS A DOLOMITIC ROCK (EXTRACLASTS) 2) REPLACEMENT 3) IF THE FRAGMENTS ARE INTRACLASTS. THE DOLOMITE IS AN EARLY DOLOMITE.

MAGNIFICATION IN THE MICROSCOPE: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20X = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 6-27-69-22W5 (1 OF 2)
DEPTH: 5061'
MICROFACIES 1: FACIES WPB

LITHOLOGY	DOLOMITE
TEXTURAL CLASSIFICATION	DOLOWACKESTONE
POROSITY	22% MOLDIC 27% 5% VUGGY THE PORES ARE TOTALLY OR PARTIALLY FILLED BY RESIDUAL OIL
MINERALOGY	Do 99% CALCITE 1% PHOSPHATE LESS THAN 1% QUARTZ LESS THEN 1%
FABRIC	BIVALVES AND/OR BRACHIOPODS. NOW MOLDS 22% FORAMS? (AGAIN THIS BROWN FEATURES LIKE CAMERAS WITH SOME AGGREGATE OF QUARTZ, SOME DOLOMITE CRYSTALS) 1% PELOIDS LESS THAN 1% THE SHELLS ARE IN CONCORDANT POSITION
DOLOMITE	A) REPLACEMENT: ANHEDRAL TO SUBHEDRAL CRYSTALS OF SMALL SIZE (40um TO 80um) B) VOID FILLING: SUBHEDRAL Do, SMALL (60Um), ABUNDANCE 2%. IT GROWS PERPENDICULAR OF SOME SHELLS (THIS PARTICULAR CEMENT SEEMS TO REPLACING A 'DIENTE DE PERRO' CEMENT)
OTHER CEMENT TYPES	SPAR CALCITE 1% FILLING THE MOLDS AND VUGGS. WITHIN THE Ca SPAR CAN BE SEEN DOLOMITE CRYSTALS IMPLICATION: DIAGENETIC ENVIRONMENT OF THE FORMATION OF Ca (METEORIC); DIAGENETIC ENVIRONMENT OF THE FORMATION OF Do. (BURIAL Do)

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE A
WELL: 6-27-69-22W5 (2 OF 2)
DEPTH: 5061'
MICROFACIES 1: FACIES WPB

QUARTZ	SMALL GRAINS (10 TO 20 UNITS IN 20x) (COARSE SILT TO VERY FINE SAND) IT IS EQUIVALENT IN SIZE TO THE Do REPLACING THE MATRIX.
DIAGENETIC PROCESSES	DISSOLUTION (MOLDIC) CEMENTATION (Ca,Do?) REPLACEMENT OIL MIGRATION

MAGNIFICATION IN MICROSCOPE: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

STURGEON LAKE B
WELL: 11-19-68-21W5
DEPTH: 5095'3"
MICROFACIES 5B: FACIES C

MINERALOGY	QUARTZ ZIRCON TOURMALINE CHERT METAMORPHIC FR. PLAGIOCLASE MUSCOVITE
POROSITY	10% PRIMARY (INTERPARTICLE)
VOID FILLING	2% CRYSTALS OF DO (6 TO 11 UNITS IN 10x) (SMALL)
MATRIX	50%DOLOMITIC (REPLACEMENT) THE MATRIX IS NOT SO ARGILLACEOUS. THE Do CRYSTAL FOR THE SAMPLE ARE BIGGER AND BETTER DEVELOPED THAN AN AVERAGE SAMPLE.
GRAINS	CONTACTS: GRAIN/MATRIX, LONGITUDINAL AND TANGENTIAL MODERATELY SORTED, SUBANGULAR TO SUBROUNDED GRAINS (4 TO 12 UNITS IN 10x) (COARSE SILT TO VERY FINE SANDSTONE)

MICROSCOPE MAGNIFICATION: 3.2x = 40 UNITS = 1mm
10x = 100 UNITS = 0.8mm
20x = 100 UNITS = 0.4mm

SUMMARY

MICROFACIES 1: FACIES WPB

SAMPLES: 15-18-68-21W5 DEPTH 5131'6" (1579.57M)
7-23-68-22W5 DEPTH 5110'6" (1573.17M)
6-27-69-22W5 DEPTH 5061' (1542.99M)
7-27-68-22W5 DEPTH 5135'8" (1585.87M)

Dolowackestone of bivalves and/or brachiopods and lingulas

MINERALOGY	Mainly dolomite Quartz from less than 1% to 20% Phosphates 1 to 4%
FABRIC	Molds of bivalves and/or brachiopods: 15 to 22% Gastropods (occasionally) Lingula fragments: 0 to 10% Arenaceous forams 1% Peloids 0 to 10% The shells are moderately to well sorted in concordant position
POROSITY	7 to 27% moldic and vuggy -it should be noted that if you compare porosities values between microfacies 1 and microfacies 5 they are more or less equal, nevertheless the kmax values are different. In microfacies 1 the permeabilites are approximately 400md. For microfacies 5 the permeabilities are around 21md.
DOLOMITE	Two types: A) replacement of the matrix, anhedral to subhedral, yellowish, cloudy, small to medium. (small=>100um, medium=100um-500um) In one sample you can see sucrosic euhedral do. B) as a void filling (may be replacement and/or cement), less cloudy, bigger do (still in the range of small to medium), euhedral, distributed around the molds or pores 0 to 4%
CEMENT	Quartz (within this cement you can see some ghosts of do.) Calcite (spar) 1% when present In the dolowackestone of microfacies 3 there is 7 to 20% of cement that can be either quartz or gypsum

QUARTZ	Silt to very fine sandstone, moderately to well sorted, subangular to subrounded grains (borders eating by do) In spite of the differences in the percentages of quartz for any sample if you plot the % values in a well location there is not any clear trend in the distribution of those values so there is not an evident source of quartz or palaeocoastal line
COMMENTS	In some cases there is presence of residual oil Is the void filling replacements or cement? Quartz or gypsum?
ASSUMPTION	Within the calcite cement (spar) there are small crystals of dolomite. If the diagenetic environment of the ca is meteoric and the dolomite came after, then the do is a burial dolomite.
DIAGENETIC PROCESSES	Replacement of the matrix Dissolution of shells Cementation of:ca, qz, gypsum? Dolomite?

MICROFACIES 2: Facies F -> Breccia

Only one sample -> look at the description.

sample 9-4-69-22w5 -> 5156'3"

MICROFACIES 3: Facies WPB/M -> contact.

Samples: 5-19-68-21W5 DEPTH 5080'2" (1553.86M)
3-24-68-22W5 DEPTH 5268' (1606.10M)
15-4-69-21W5 DEPTH 4838'?? (1475M??)
14-10-68-22W5 DEPTH 5268' (1606.10M)
13-24-68-22W5 DEPTH 5069'3" (1545.43M)

Contact between dolowackestone of brachiopods and a dolomudstone. The dolowackestone corresponds to microfacies 1.

NATURE OF THE CONTACT	Very sharp, sometimes pyritized, irregular (erosive?). Sometimes stylolite
DOLOMUDSTONE	Massive, laminated in some cases

MINERALOGY	Dolomite Quartz 1 to 3% Phosphates 0 to 4% Opaque minerals 0 to 4%
DOLOMITE	Replacement of the micrite Anhedral crystals -> small
QUARTZ	Silt. Subrounded to subangular grains
POROSITY	0% One sample with 7% of intercrystalline porosity

MICROFACIES 4: FACIES WPB

Sample: 9-24-68-21W5 DEPTH 5103'2"

see descriptions

MICROFACIES 5: FACIES 5

Samples: 7-4-69-21W5 -> DEPTH: 4963' (1513.11M)
5-19-68-21W5 -> DEPTH: 5088'(1551.22M)
6-11-68-21W5 -> DEPTH: 5237'(1596.65M)
7-26-68-21W5 -> DEPTH: 5231'9"(1617.68M)
7-5-69-21W5 -> DEPTH: 4943'6"(1522.25M)
5-32-68-21W5 -> DEPTH: 4991'6"(1536.89M)
9-6-69-21W5 -> DEPTH: 4917'6"(1514.33M)
13-4-69-21W5 -> DEPTH: 4943'(1507.01M)

Interlaminations of quartz-arenites and hybrid sandstones. The matrix is a mixture of argillaceous material and dolomite (replacement of the matrix). Irregular laminae with an average thickness of 0.2mm.
Hybrid sandstones -> 30 to 60%
quartz arenites -> 70 to 40%

MINERALOGY	Quartz Muscovite 0 to 1% Plagioclase 0 to 2% Chert 0 to 4% Metamorphic fragments 0 to 4% Tourmaline 0 to 3% Zircon 0 to 1% Glauconite Microcline 0 to 1% Pyrite
MATRIX	20% to 50%
POROSITY	7 to 25% (average 20%) primary (interparticle) Normally present in the quartzarenites.
DOLOMITE **AS A** **VOID FILLING**	Euhedral, cloudy, mainly small (>100um) ocasionally medium (100um-500um). Distributed within the pores (occasionally like a floating grain (sucrosic dolomite)). Most of the cases you see cloudy nucleus (normally rounded in shape) followed by cleaner faces euhedral in shape. 3 to 10% (average 7%)
CEMENTS	Dolomite as patches (spar) 0 to 10% Characteristics: it reacts with Hcl, pink and grey under polarized light Doesn't stain Quartz overgrowth: 0 to 1%
COMMENTS	In general, the samples are moderately sorted, angular to subrounded grains. Grain sizes range from medium silt to very fine sandstone (being the most common), coarse silt to vf sandstone. Contacts: grain/matrix, longitudinal, tangential

MICROFACIES 5A: FACIES C

Sample: 13-6-69-21W5

5A in general has much more matrix than 5. The laminae of quartzarenites/quartz wackes has also more matrix with organic matter. See description for details.

MICROFACIES 5B: FACIES C

Sample: 13-36-68-21W5 -> DEPTH: 5063'6"(1558.84M)

11-19-68-21W5 -> DEPTH: 5095'3"(15560.97M)

15-18-68-21W5 -> DEPTH: 5144'(1568.29M)

Microfacies 5B is equivalent to microfacies 5 but is bioturbated. The laminae are not well preserved so the distribution of the hybrid sandstone as well as the quartz arenites is irregular.

MINERALOGY	Quartz Muscovite Plagioclase Zircon Microcline Chert Pyrite Tourmaline Dolomitic shells
MATRIX	15% to 50%
VOID FILLING	2 to 7% small, cloudy, euhedral crystals of do.
POROSITY	10 to 35% primary (interparticle)
GRAINS	Coarse silt to vf sandstone, moderately sorted. Contacts: grain/matrix, longitudinal, tangential

MICROFACIES 6: FACIES D

Sample: 13-6-69-21W5 -> DEPTH: 4891'4"(1501.32M)

9-7-69-21W5 -> DEPTH: 4884'6"(1504.26M)

5-18-69-21W5 -> DEPTH: 4904'6"(1510.36M)

MINERALOGY	Quartz Muscovite Ghost of shells now dolomitized 0 to 1% Intraclasts 0 to 1% Glauconite grains Chert Metamorphic fr. Plagioclase Tourmaline Phosphate (lingulas) 0 to 3% Microcline Leucoxene 0 to 3% Rutile 0 to 1%
MATRIX	----------
POROSITY	5 to 20% primary (interparticle)
CEMENT	Quartz overgrowth 0 to 2% Patches of spar dolomite 0 to 20%
VOID FILLING	Euhedral with cloudy nuclei, small, 10 to 20%
GRAINS	Coarse silt to vfs. Well sorted, subangular to subrounded grains

MICROFACIES 7: FACIES E

Just one sample (6-11-68-21W5). Read description.

B
(SW)

5-32-68-21W5
Poco Sturls

Devonian
KBE : 2140.20' (652 m)
TD : 8525.35' (2598.5 m)
FD : 1956

600 m

9-31-68-21W5
Poco Sturls

Devonian
KBE : 2136.26' (651 m)
TD : 8490.57' (2588 m)
FD : 1955

550 m

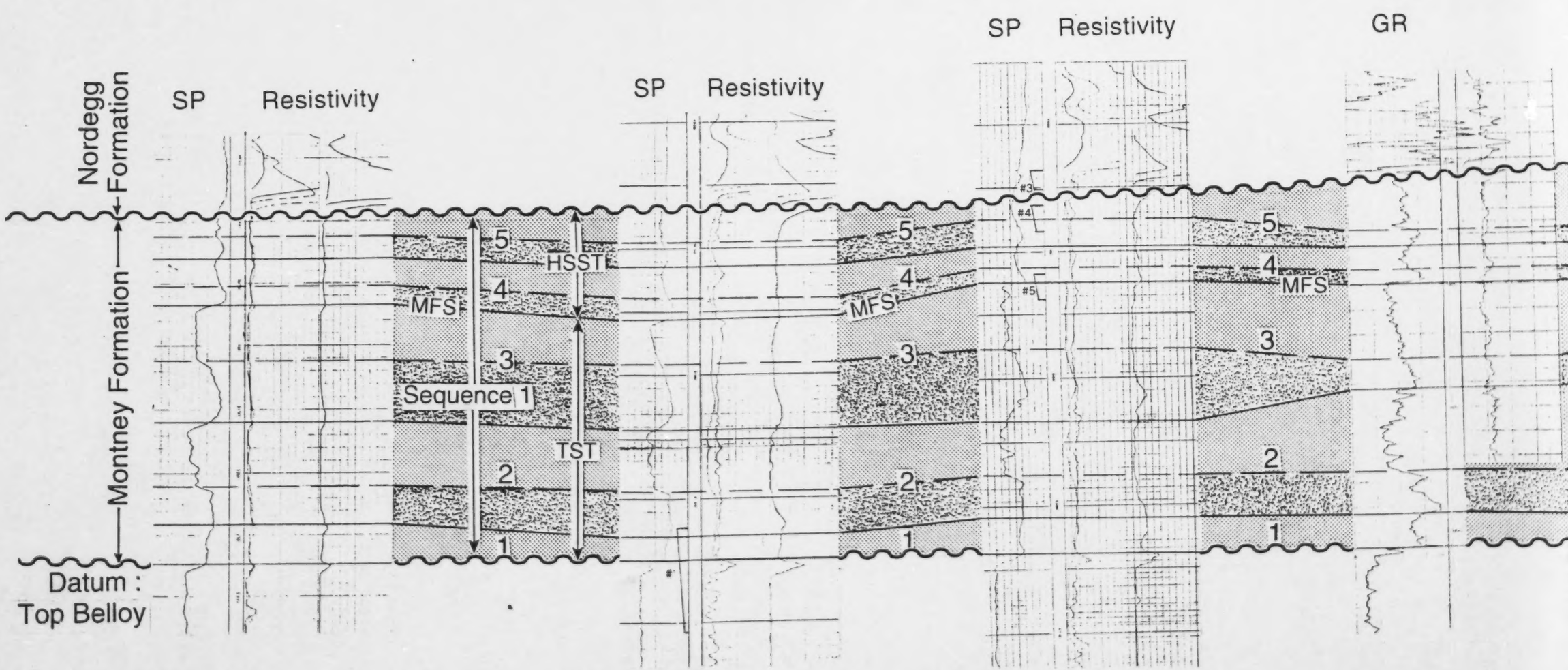
15-31-68-21W5
Poco Sturls

Devonian
KBE : 2122.15' (647 m)
TD : 8583.42' (2616 m)
FD : 1954

700 m

3-6-69-21W5
Triad South Sturgeon Lake

Devonian
KBE : 2109.03' (643 m)
TD : 8418.39 (2566 m)
FD : 1956



15-31-68-21W5
Poco Sturls

Devonian
KBE : 2122.15' (647 m)
TD : 8583.42' (2616 m)
FD : 1954

700 m

3-6-69-21W5
Triad South Sturgeon Lake

Devonian
KBE : 2109.03' (643 m)
TD : 8418.39 (2566 m)
FD : 1956

550 m

5-6-69-21W5
Triad South Sturgeon Lake

Devonian
KBE : 2100.17' (640 m)
TD : 8443.33' (2573.5 m)
FD : 1956

700 m

9-1-69-22W5
Esso Sturgeon Lake South #A-9-1

Devonian
KBE : 2103.12' (641 m)
TD : 8418.39 (2566 m)
FD : 1955

600 m

15-1-69-22W5
Esso Sturgeon Lake South A

Devonian
KBE : 2142.16' (653 m)
TD : 8477.45 (2584 m)
FD : 1955

500 m

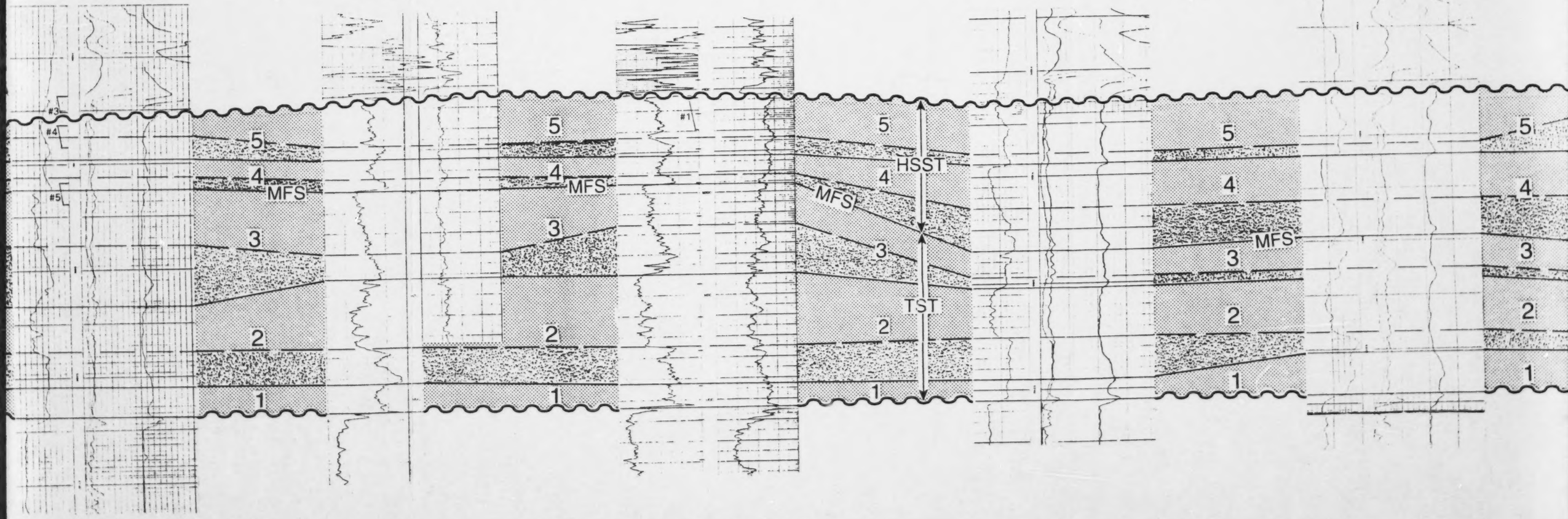
SP Resistivity

GR

GR

SP Resistivity

SP Resistivity



700 m

9-1-69-22W5
Esso Sturgeon Lake South #A-9-1

Devonian
KBE : 2103.12' (641 m)
TD : 8418.39 (2566 m)
FD : 1955

600 m

15-1-69-22W5
Esso Sturgeon Lake South A

Devonian
KBE : 2142.16' (653 m)
TD : 8477.45 (2584 m)
FD : 1955

500 m

3-12-69-22W5
Hess HB Union Crown

Devonian
KBE : 2147.09' (654.5 m)
TD : 8447.26' (2575 m)
FD : 1956

600 m

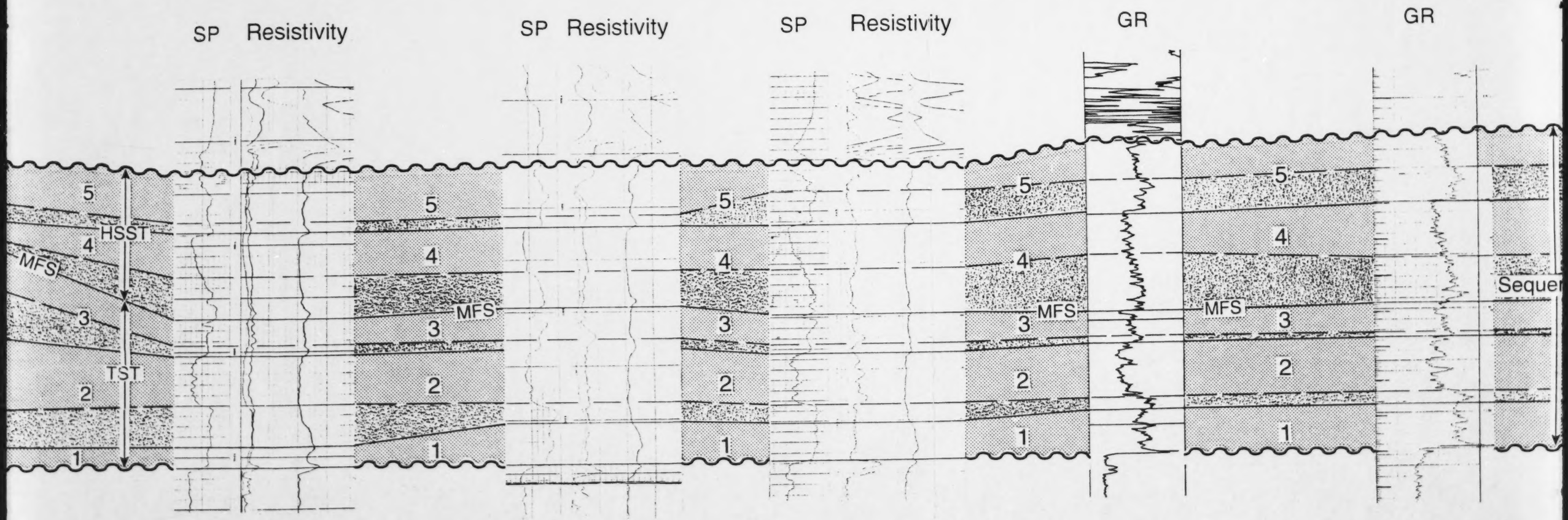
5-12-69-22W5
Hess HB Union Crown

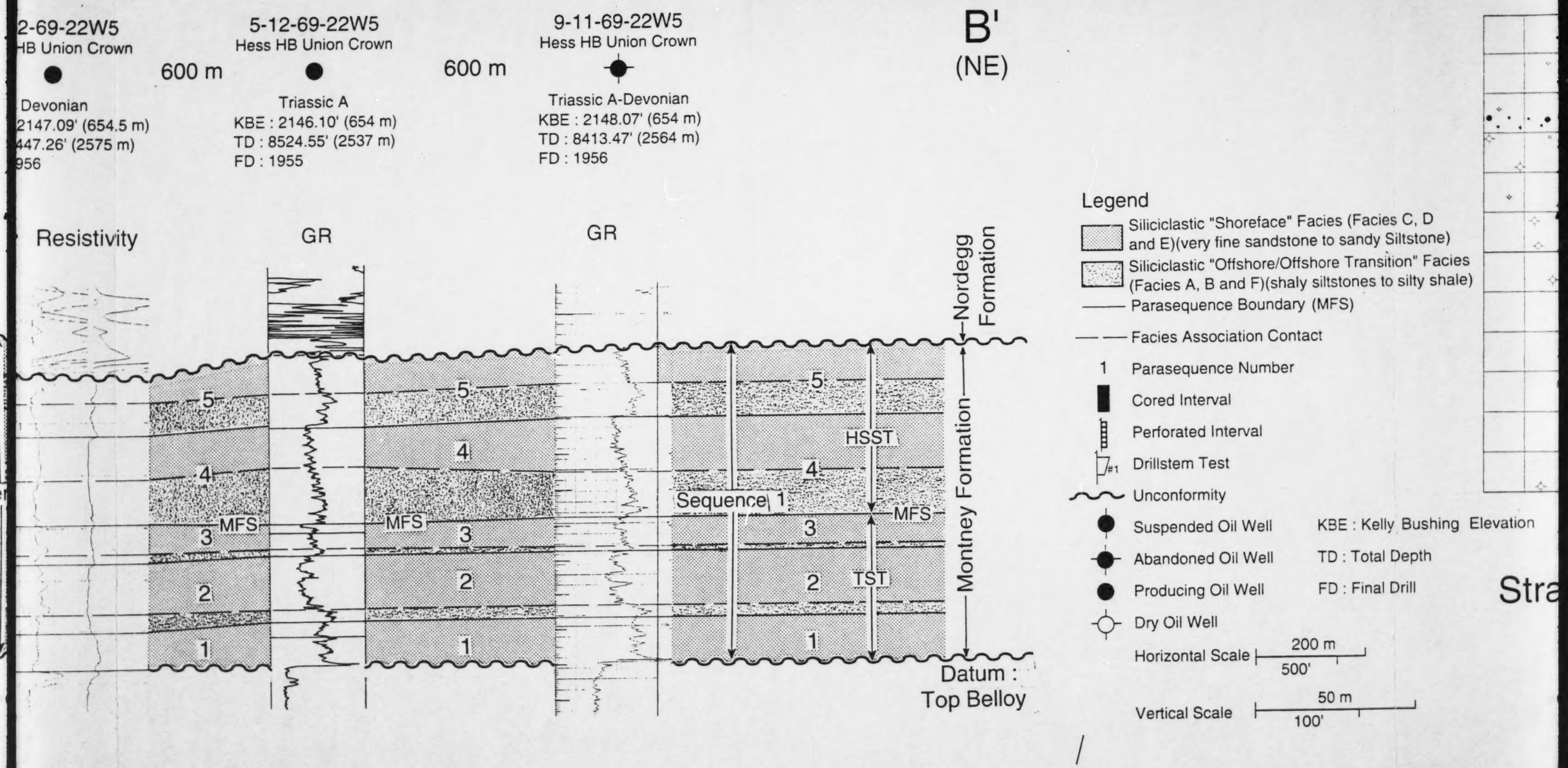
Triassic A
KBE : 2146.10' (654 m)
TD : 8524.55' (2537 m)
FD : 1955

600 m

9-11-69-22W5
Hess HB Union Crown

Triassic A-Devonian
KBE : 2148.07' (654 m)
TD : 8413.47' (2564 m)
FD : 1956

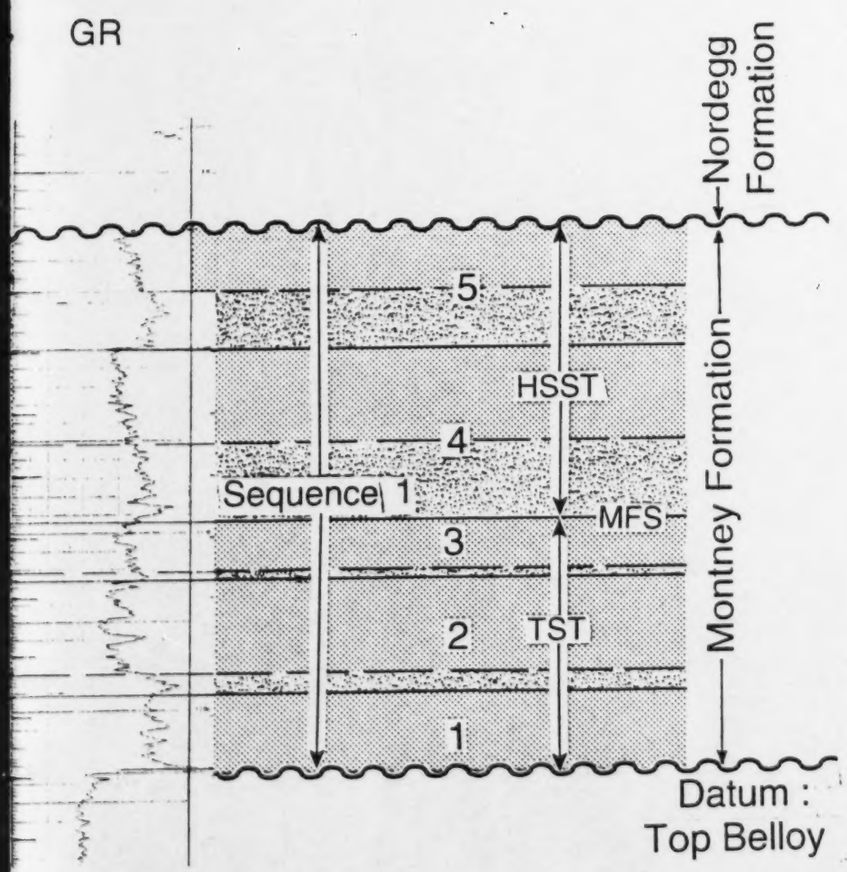



2-69-22W5
HB Union Crown
Devonian
2147.09' (654.5 m)
447.26' (2575 m)
956
600 m
5-12-69-22W5
Hess HB Union Crown
Triassic A
KBE : 2146.10' (654 m)
TD : 8524.55' (2537 m)
FD : 1955
600 m
9-11-69-22W5
Hess HB Union Crown
Triassic A-Devonian
KBE : 2148.07' (654 m)
TD : 8413.47' (2564 m)
FD : 1956
B'
(NE)
Resistivity
GR
GR
Nordegg Formation
Montney Formation
HSST
TST
MFS
MFS
MFS
Sequence 1
5
4
3
2
1
Datum :
Top Belloy
Legend
Siliciclastic "Shoreface" Facies (Facies C, D and E)(very fine sandstone to sandy Siltstone)
Siliciclastic "Offshore/Offshore Transition" Facies (Facies A, B and F)(shaly siltstones to silty shale)
Parasequence Boundary (MFS)
Facies Association Contact
1 Parasequence Number
Cored Interval
Perforated Interval
#1 Drillstem Test
Unconformity
Suspended Oil Well
Abandoned Oil Well
Producing Oil Well
Dry Oil Well
KBE : Kelly Bushing Elevation
TD : Total Depth
FD : Final Drill
Horizontal Scale 200 m 500'
Vertical Scale 50 m 100'
Stra

9-11-69-22W5
ess HB Union Crown

Triassic A-Devonian
BE : 2148.07' (654 m)
D : 8413.47' (2564 m)
D : 1956

B'
(NE)



Legend

- Siliciclastic "Shoreface" Facies (Facies C, D and E)(very fine sandstone to sandy Siltstone)
- Siliciclastic "Offshore/Offshore Transition" Facies (Facies A, B and F)(shaly siltstones to silty shale)
- Parasequence Boundary (MFS)
- Facies Association Contact
- 1 Parasequence Number
- Cored Interval
- Perforated Interval
- #1 Drillstem Test
- Unconformity
- Suspended Oil Well
- Abandoned Oil Well
- Producing Oil Well
- Dry Oil Well

KBE : Kelly Bushing Elevation
TD : Total Depth
FD : Final Drill

Horizontal Scale 200 m / 500'

Vertical Scale 50 m / 100'

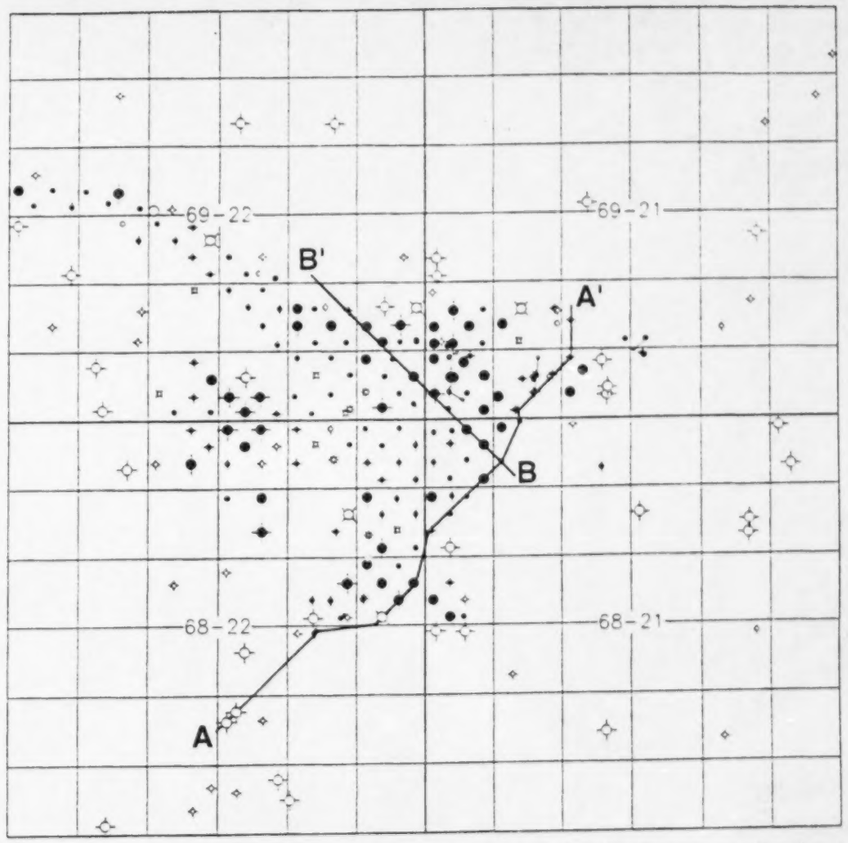


Figure 38: Cross-section B-B' for the Sturgeon Lake Area

Stratigraphic Strike Section
B – B'
Sturgeon Lake Area
Montney Formation

Selena Mederos, 1994

A
(SW)

12-10-68-22W5
penzl et al N. L. Smoky

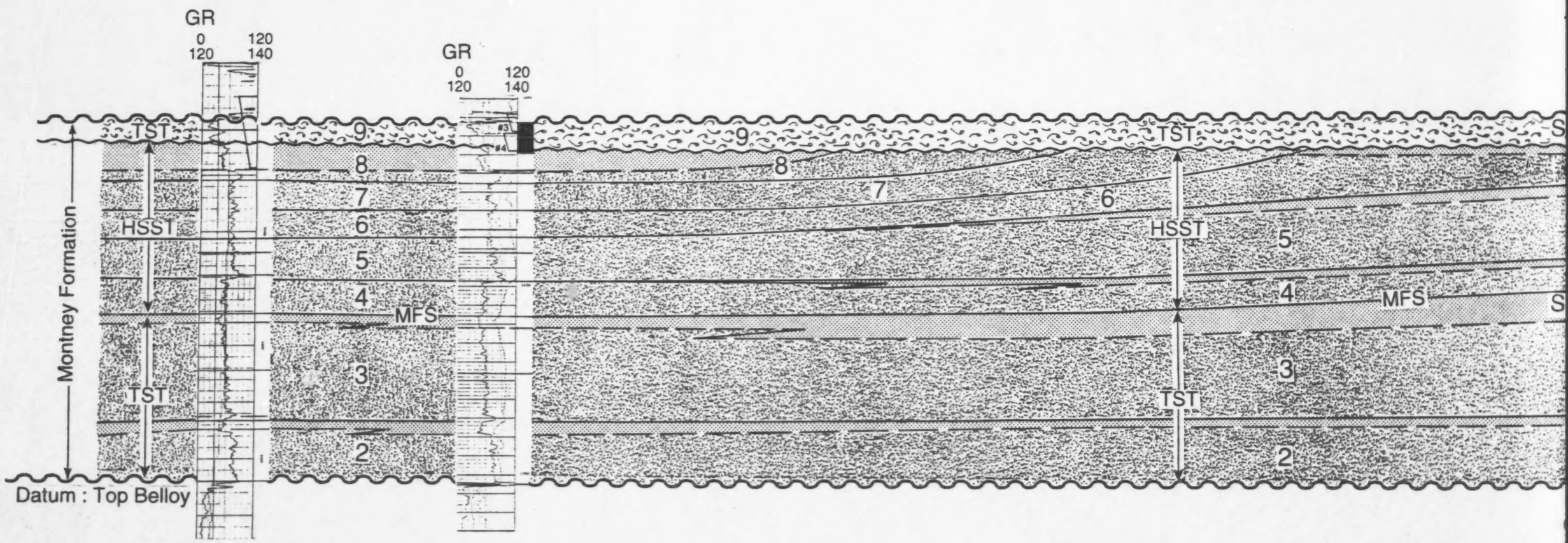
400 m

14-10-68-22W5
Canhunter Sturls

2600 m

KBE : 2200.11' (673 m)
TD : 8640.51' (2634 m)
FD : 1966

KBE : 2193.01' (668.6 m)
TD : 6199.20' (1890 m)
FD : 1988

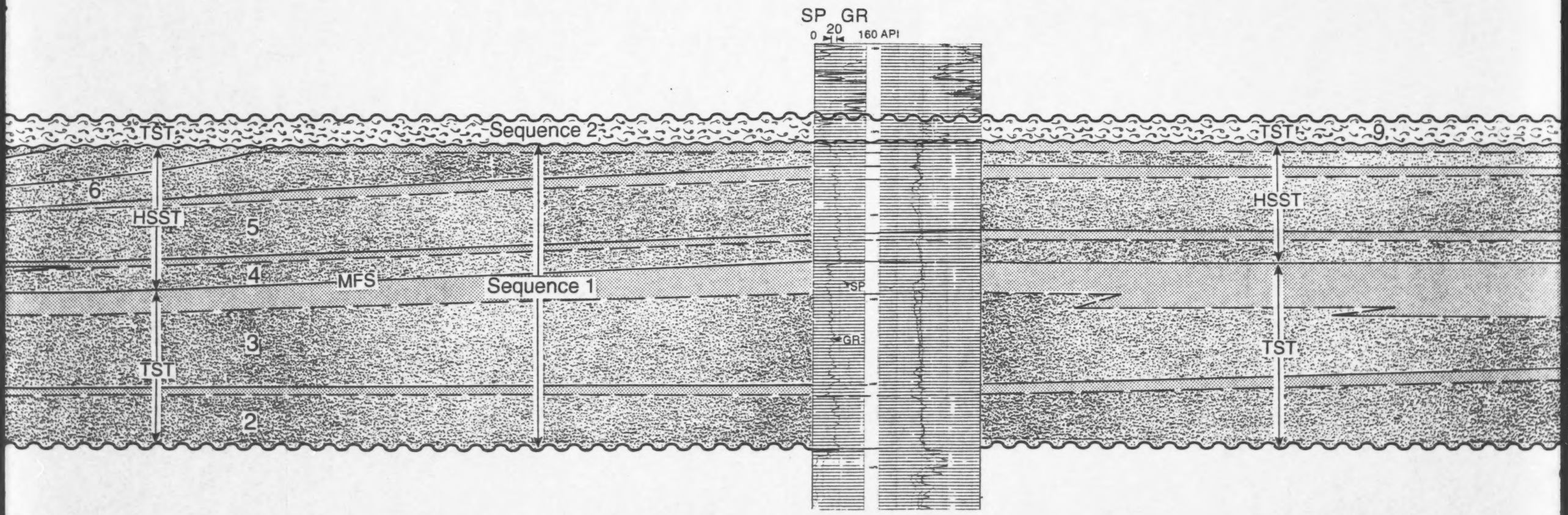


14-14-68-22W5
Horgan et al Sturls

KBE : 2162.18' (659.2 m)
TD : 8649.36' (2637 m)
FD : 1989

2600 m

1750 m



14-14-68-22W5
Horgan et al Sturls

KBE : 2162.18' (659.2 m)
TD : 8649.36' (2637 m)
FD : 1989

1750 m

3-24-68-22W5
Triad Sturls In

Suspended Triassic B
KBE : 2153.98' (656.5 m)
TD : 5275.19' (1608 m)
FD : 1958

600 m

7-24-68-22W5
Triad South Sturgeon Lake

Suspended Triassic B
KBE : 2126.09' (648 m)
TD : 5133.12' (1564.6 m)
FD : 1958

500 m

SP GR
0 20 160 API

GR

GR

G

TST

HSST

TST

MFS

MFS

SP

GR

9

9

9

5

3

2

3-24-68-22W5
Triad Sturls In

Suspended Triassic B
KBE : 2153.98' (656.5 m)
TD : 5275.19' (1608 m)
FD : 1958

600 m

7-24-68-22W5
Triad South Sturgeon Lake

Suspended Triassic B
KBE : 2126.09' (648 m)
TD : 5133.12' (1564.6 m)
FD : 1958

500 m

9-24-68-22W5
Triad South Sturgeon Lake

Triassic B
KBE : 2115.26' (645 m)
TD : 8780.28' (2676 m)
FD : 1957

1250 m

5-30-68-
Poco S

Devon
KBE : 2103.1
TD : 8457.43
FD : 1955

GR SP Resistivity

GR

GR

SP R

20

9

9

5

HSST

5

MFS

MFS

MFS

3

TST

2

2

9-24-68-22W5
Triad South Sturgeon Lake

Triassic B
KBE : 2115.26' (645 m)
TD : 8780.28' (2676 m)
FD : 1957

1250 m

5-30-68-21W5
Poco Sturls

Devonian
KBE : 2103.12' (641 m)
TD : 8457.43' (2578 m)
FD : 1955

600 m

11-30-68-21W5
Poco Sturls

Devonian
KBE : 2105.09' (642 m)
TD : 8527.32' (2599 m)
FD : 1955

1100 m

1-31-68-2
Poco Stu

Devonia
KBE : 2141.18
TD : 8496.48'
FD : 1955

SP Resistivity

20

SP Resistivity

SP Resistivity

GR

HSST

MFS

TST

5

4

3

2

Belloy

-68-21W5
co Sturls

evonian
03.12' (641 m)
7.43' (2578 m)
5

600 m

11-30-68-21W5
Poco Sturls

Devonian
KBE : 2105.09' (642 m)
TD : 8527.32' (2599 m)
FD : 1955

1100 m

1-31-68-21W5
Poco Sturls

Devonian
KBE : 2141.18' (658 m)
TD : 8496.48' (2590 m)
FD : 1955

600 m

5-3[illegible]-68-21W5
Poco Sturls

Devonian
KBE : 2140.20' (652 m)
TD : 8525.35' (2598.5 m)
FD : 1956

14-32
Poco

D
KBE : 2
TD : 84
FD : 19

Resistivity

SP

Resistivity

GR

GR

GR

5
4
3
2
1

HSST
MFS
TST
MXFS

Belloy

-Stur

8-21W5
Sturls

onian
.18' (658 m)
48' (2590 m)

600 m

5-32-68-21W5
Poco Sturls

Devonian
KBE : 2140.20' (652 m)
TD : 8525.35' (2598.5 m)
FD : 1956

14-32-68-21W5
Poco et al Sturls

Devonian
KBE : 2144.15' (653.7 m)
TD : 8455.84' (2578 m)
FD : 1991

400 m

3-5-69-21W5
Poco Sturls

Devonian
KBE : 2139.21' (652 m)
TD : 8489.26' (2587.5 m)
FD : 1957

600 m

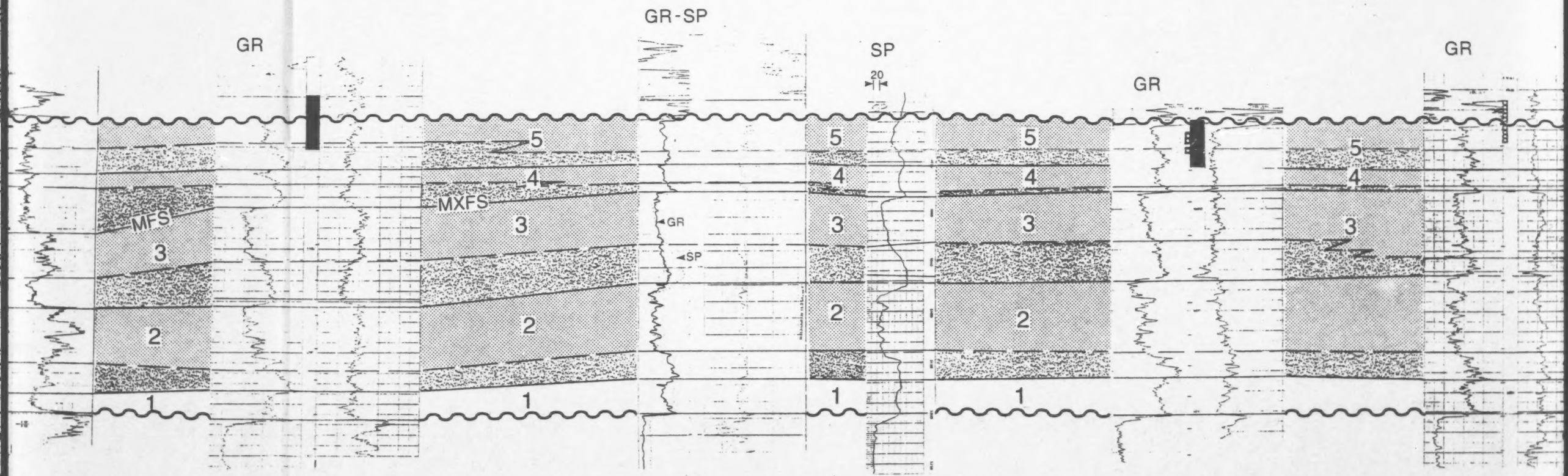
7-5-69-21W5
Poco Sturls

Devonian Triassic
KBE : 2159.23' (658 m)
TD : 8395.42' (2559 m)
FD : 1957

700 m

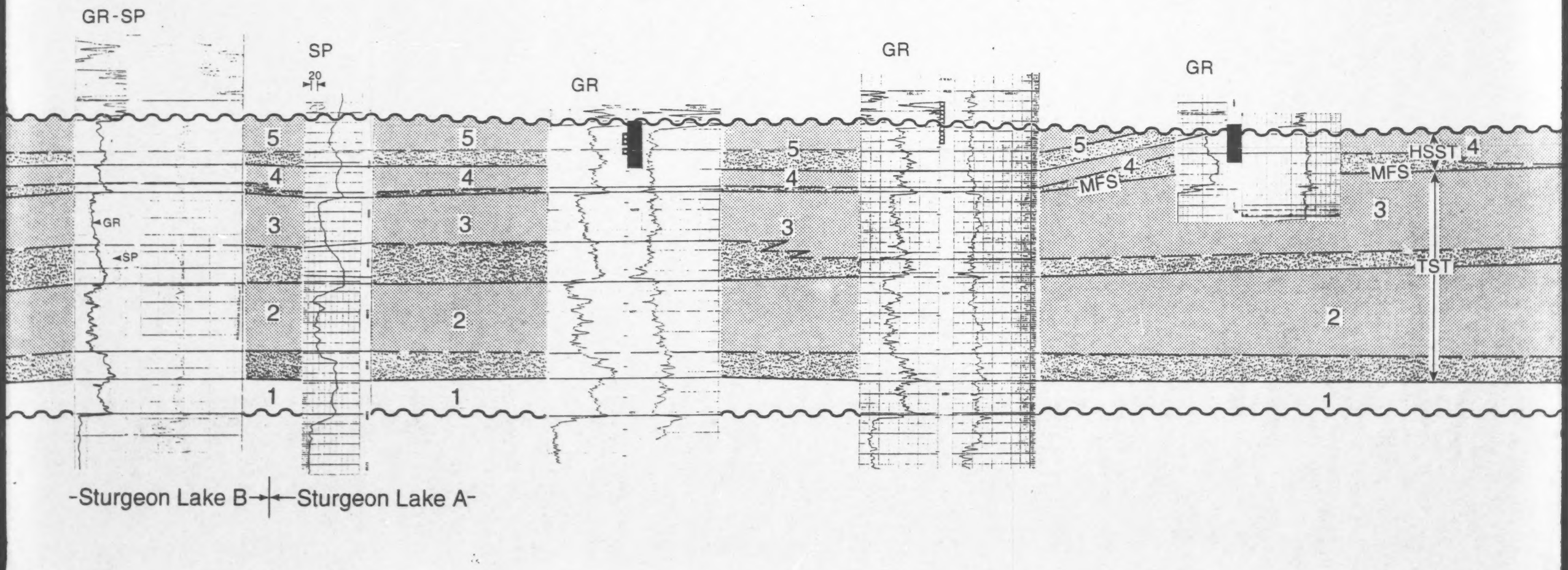
9-5-69-21W5
Poco Sturls

Triassic
KBE : 2173,99' (662
TD : 8549.33' (2605
FD : 1957



-Sturgeon Lake B-→←-Sturgeon Lake A-

14-32-68-21W5	400 m	3-5-69-21W5	600 m	7-5-69-21W5	700 m	9-5-69-21W5	600 m	13-4-69-21W5	850 m
Poco et al Sturls		Poco Sturls		Poco Sturls		Poco Sturls		Lyons Carillon Sturls	
Devonian		Devonian		Devonian Triassic		Triassic		Triassic A	
KBE : 2144.15' (653.7 m)		KBE : 2139.21' (652 m)		KBE : 2159.23' (658 m)		KBE : 2173,99' (662 m)		KBE : 2173' (662 m)	
TD : 8455.84' (2578 m)		TD : 8489.26' (2587.5 m)		TD : 8395.42' (2559 m)		TD : 8549.33' (2605 m)		TD : 5020.26' (1530 m)	
FD : 1991		FD : 1957		FD : 1957		FD : 1957		FD : 1964	



9-5-69-21W5
Poco Sturls

700 m

Triassic
KBE : 2173,99' (662 m)
TD : 8549.33' (2605 m)
FD : 1957

13-4-69-21W5
Lyons Carillon Sturls

600 m

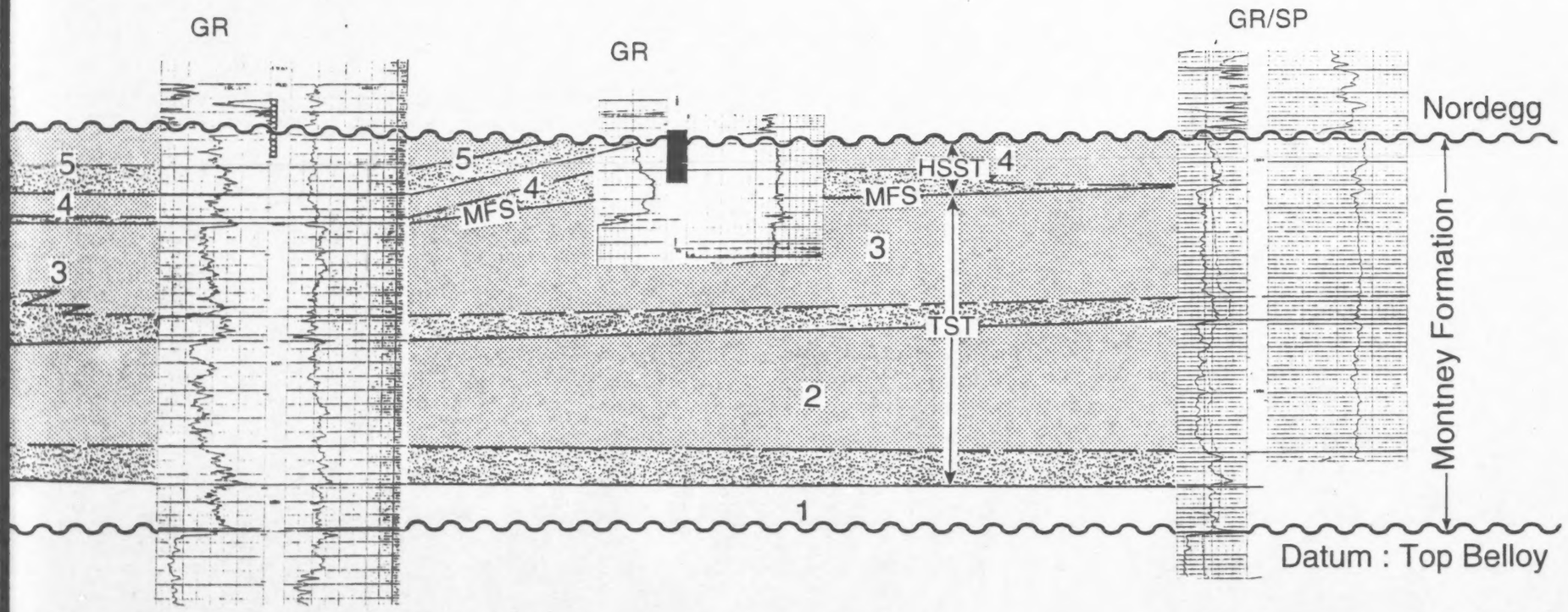
Triassic A
KBE : 2173' (662 m)
TD : 5020.26' (1530 m)
FD : 1964

5-9-69-21W5
Lyons Carillon Sturls

850 m

Devonian
KBE : 2165.13' (660.1 m)
TD : 9446.40' (2880 m)
FD : 1984

A'
(NE)



Legend

- Siliciclastic "Shoreface" Facies (Facies C, D and E)(very fine sandstone to sandy Siltstone)
- Siliciclastic "Offshore/Offshore Transition" Facies (Facies A, B and F)(shaly siltstones to silty shale)
- Bioclastic Shoreface Facies
- Parasequence Boundary (MFS)
- Facies Association Contact
- 1 Parasequence Number
- Cored Interval
- Perforated Interval
- #1 Drillstem Test
- Unconformity

MXFS: Max-Flooding
KBE : Kelly Bushing
TD : Total Depth
FD : Final Drill

- Suspended Oil Well
- Abandoned Oil Well
- Producing Oil Well
- Dry Oil Well

Horizontal Scale: 500 m / 1000'

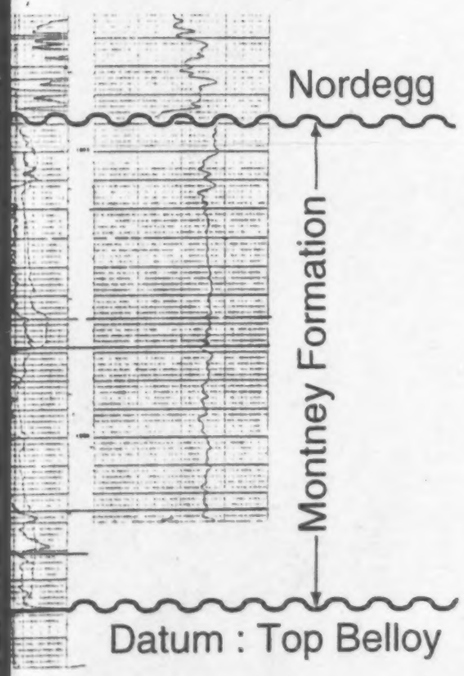
Vertical Scale: 50 m / 200'

5-9-69-21W5
ons Carillon Sturls

Devonian
E : 2165.13' (660.1 m)
: 9446.40' (2880 m)
: 1984

A'
(NE)

GR/SP



Legend

- Siliciclastic "Shoreface" Facies (Facies C, D and E)(very fine sandstone to sandy Siltstone)
- Siliciclastic "Offshore/Offshore Transition" Facies (Facies A, B and F)(shaly siltstones to silty shale)
- Bioclastic Shoreface Facies
- Parasequence Boundary (MFS)
- Facies Association Contact
- 1 Parasequence Number
- Cored Interval
- Perforated Interval
- #1 Drillstem Test
- Unconformity
- MXFS: Max-Flooding Surface
- Suspended Oil Well
- KBE : Kelly Bushing Elevation
- Abandoned Oil Well
- TD : Total Depth
- Producing Oil Well
- FD : Final Drill
- Dry Oil Well

Horizontal Scale 500 m / 1000'

Vertical Scale 50 m / 200'

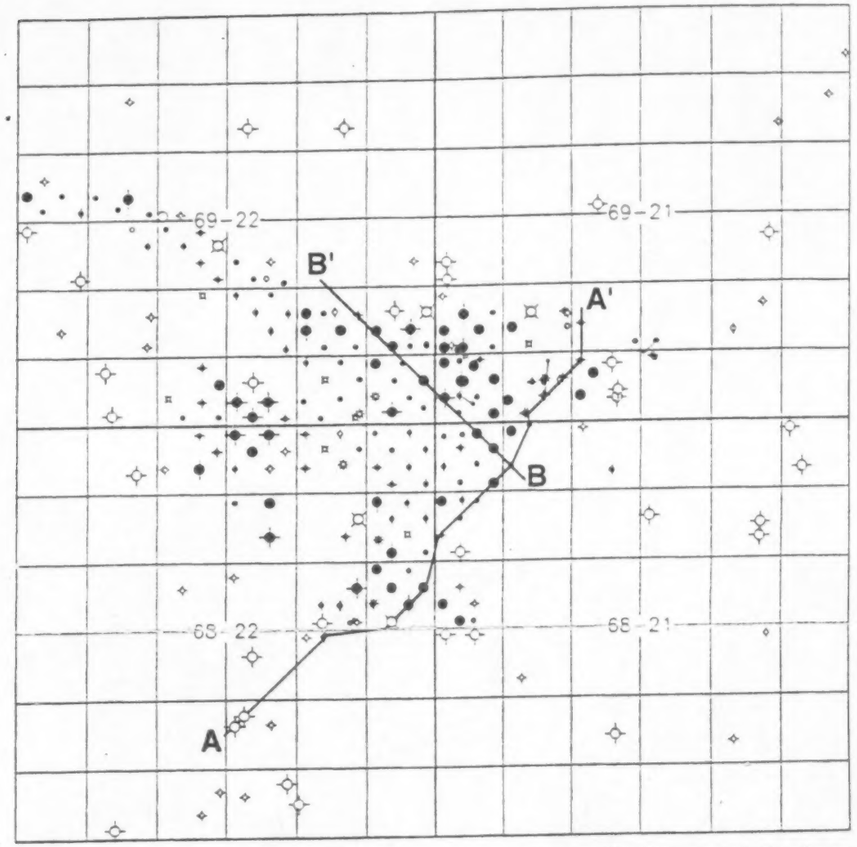


Figure 37: Cross-section A-A' for the Sturgeon Lake Area

Stratigraphic Dip Section
A – A'
Sturgeon Lake Area
Montney Formation
Selena Mederos, 1994